The
Practical Engineer

A monthly journal, devoted to the economical generation and utilization of power and to the interests of stationary engineers

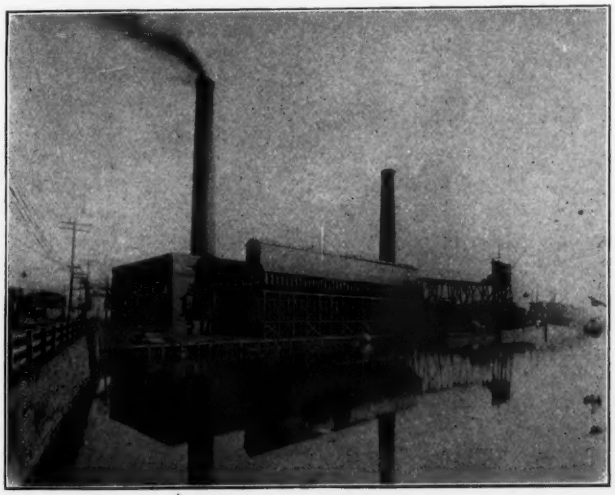
VOL. X. PHILADELPHIA, AUGUST, 1906. No. 7.

RETURN TO 207 MARKET ST.

A NEW ENGLAND RAILWAY POWER STATION

BY FRANK C. PERKINS.

The accompanying illustrations show the exterior and interior of the Grand Avenue Power Plant of the Consolidated Railway Co., at New Haven, Ct. The exterior view shows method of operation, and the equipment of the coal handling



Exterior of the Grand Avenue Power Plant

apparatus of this station, with mast and gaff hoisting outfits, and automatic railway for handling the fuel supply. This power house is nearly 200 feet long and about 80 feet wide, with two chimneys 140 feet high, one of which has an internal diameter of nine feet, and the other six and one-half feet. The engine room extends the entire length of the building, nearly 200 feet, and is about 50 feet wide and 30 feet high, while the boiler room is nearly as long, and measures nearly 40 feet high and 30 feet wide. The boiler house is provided with vertical fire tube boilers of the Manning type, which are arranged for hand stoking, supplying steam to the engines at a pressure of 120 lbs. per square inch. There are ten boilers of 125 horse power, each having 188 tubes, and there are also installed in this boiler room nine boilers of 200 horse power each, with 284 tubes, each 2½ inches diameter. The larger boilers have a grate area of nearly 40 square feet, and the smaller boilers nearly 30 square feet, the heating surface of these boilers being 2,918 square feet and 1,950 square feet, respectively. This boiler plant, therefore, has a total grate area of more than 600 square feet and a total heating surface of more than 45,000 square feet.

As will be noted by the illustration of the engine room, there are several types of electrical generators in operation, driven by both vertical and horizontal engines. The largest unit is a 900 kilowatt Crocker Wheeler railway generator, which has recently been installed, having an efficiency of 93.5 per cent. at full load, and 93 per cent. at ¾ load. This generator has 16 poles and supplies a current of 600 volts. It is driven at a speed of 102 revolutions per minute, by a horizontal cross-compound Buckeye engine having a capacity of 1400 horse power. The engine occupies a floor space of 957 square feet, and is provided with piston valves and cranks placed at an angle of 90 degrees. This engine has a high-pressure piston rod 4⅝ inches in diameter, and a low-pressure piston rod 6½ inches in diameter, the connecting rod having a length of 11 feet. The shaft is 22 feet in length and has a

1400 H. P. Buckeye Engine driving Crocker-Wheeler Generator

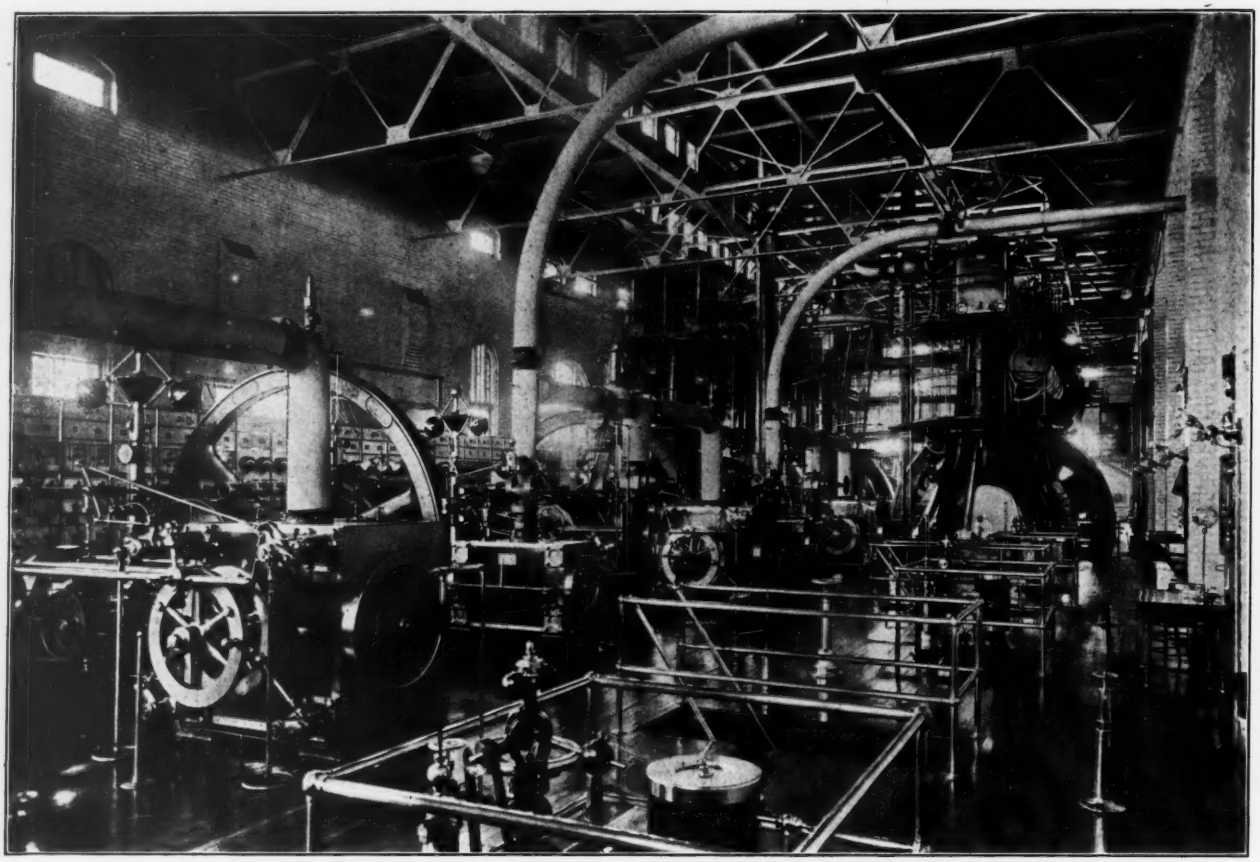
diameter of 26 inches, the bearing measuring 30 inches by 17 inches. On this unit there is a flywheel of 40,000 lbs. weight, having a diameter of 15 feet. A jet condenser of the Warren twin-cylinder type is provided with this engine and the ma-

chinery is oiled by a gravity system from a storage tank having a capacity of about 25 barrels.

In this station there are also two 800 kilowatt General Electric dynamos, supplying a current of 550 volts. These are 14 pole machines, and are directly-connected to vertical cross-compound engines of the Allis type, operating at a speed of 80 revolutions per minute and developing 1,000 horse power each. These engines also have two cranks placed at an angle of 90 degrees, and occupy a floor space of 307 square feet for each engine. The cylinders are provided with Corliss valves, and the high-pressure piston rods measure 3⅞ inches in diameter, while the low-pressure cylinder rods are 4⅝ inches in diameter. The connecting rod of these engines is 11 feet in length, and the main shaft is 20 inches in diameter, with bearings 36 inches by 18 inches. The shaft is 19 feet long, and is provided with a flywheel 18 feet in diameter. These engines are regulated by centrifugal ball governors, and are each equipped with an Allis jet condenser.

There are also two other General Electric dynamos in this station, of smaller capacity, each machine having an output of 525 kilowatts at 550 volts. These dynamos are ten pole machines, and are driven at the same speed as those just mentioned, 80 revolutions per minute, by vertical cross-compound Allis engines of 750 horse power each. These engines also occupy floor space of 307 square feet for each engine, and are provided with Corliss valves, centrifugal ball governors, and cranks set at an angle of 90 degrees.

In addition to the above electrical equipment, this station has had in operation for a number of years, three Westinghouse generators of 275 kilowatts capacity each. These machines are of the eight pole type and are driven at a speed of 92 revolutions per minute by three horizontal, cross-compound Allis engines, capable of developing 350 horse power each. These engines each occupy a floor space of 380 square feet per engine, which is larger, it will be noted, than the 750 horse power engine of double the capacity and larger than the 1000 horse power Allis engines which occupy a floor space of 307 square feet, the latter being of vertical cross-compound construction.



Interior of the Grand Avenue Power Plant, New Haven, Connecticut

Will a Dynamo Generate in a Vacuum?

EDITOR THE PRACTICAL ENGINEER:

The question was recently asked: "Will a dynamo generate in a vacuum?" A thinks it will, but would not say how long it would run. B says it will not generate in a vacuum because there is no air for the machine to build from. Which is right?

Louisville, Ky. R. A. M.

This question is open for discussion.—[Ed.]

Arrangement for Lifting Ashes Wanted.

EDITOR THE PRACTICAL ENGINEER:

I would like to have some suggestion as to how I could construct some contrivance to be used by steam for removing ashes from under grates of boiler.

Little Valley, N. Y. G. S. B.

SOME PRINCIPLES OF HEAT

Thermometry, Calorimetry, Latent Heat, Transfer of Heat

Heat is a form of energy, and is manifested by the molecular motion of the particles within a body. Since it is energy, it has capacity for doing work; thus, it may cause steam to drive a piston; it may cause solids or liquids to expand and contract, or it may change the molecular condition of the bodies, as when solids are fused or liquids vaporized. Heat does not act the same as matter because a heated body is no heavier than it was before it was heated, and that unlike matter, heat can be lost, as in melting two pieces of ice by rubbing them together, in which case a quantity of heat entirely disappears.

Since heat is a form of energy, there are numerous sources from which it is derived, because energy can be transferred into heat. The energy which provides us with heat exists in both the kinetic and potential forms. The first form is illustrated by the energy of moving air and water, as in winds, tidal waves or ocean currents, and the energy in stored water or in coal is an example of potential energy. Friction, compression, percussion, or any process by which motion is gradually or suddenly arrested, produces heat.

The most general method of heat production upon the earth, however, is combustion, by which is meant chemical combination of fuels with oxygen. The most usual substances which are burned consist of hydrogen, carbon, sulphur and phosphorus, of which carbon and hydrogen are the most important. The combination of hydrogen and carbon forms the basis for all commercial fuels, such as coal, oils or gases. When one pound of pure hydrogen is burned, it develops 62,000 heat units, and when one pound of carbon is completely burned, it will give out 14,500 heat units.

The following table gives the heating of the most usual source of heat used in engineering:

	Approx. Total Heat in 1 lb. of Fuel. Thermal Units.
Hydrogen	62,000
Petroleum oils (benzine, etc.)	27,500
Petroleum, crude	20,400
Petroleum, refuse	20,000
Coal Gas	17,800
Carbon	14,500
Coal, good quality	14,000
Coke	13,500
Wood Charcoal	11,000
Wood, dried	8000
Peat, 25 per cent. moisture	7000

Other fuels which are sometimes used include straw, tan or bark and bagasse. Straw is very bulky but will give out about 8000 heat units. Tan is oak, bark which has been used in tanning and when burned dry, will give out 6100 heat units per pound. Bagasse is the name given to the fibrous portion of sugar-cane after the juice has been extracted, but unless dried, it is difficult to burn and as usually burned, only contains about 3000 heat units per pound.

A body may be said to contain two kinds of heat: the intensity of the heat and the quantity of heat. The intensity of the heat of a body is indicated by a thermometer and has nothing directly to do with the quantity of heat that a body contains. Thus, if a pound of iron has the same temperature as a pound of water, the latter will contain about eight times as much heat as the former for each degree it is cooled. Temperature is, therefore, only a measure of the heat which affects the senses. It cannot be measured directly but only by one of the effects produced by heat, usually expansion. An instrument in which expansion is made use of, for determining temperatures, is called a thermometer, or a pyrometer, if the temperatures are high. Air, mercury and alcohol are the substances generally used in thermometers. The air thermometer has great range and great accuracy and is generally used as a standard. The alcohol thermometer is used only for very low temperatures. The mercury thermometer is the most convenient form of instrument and is therefore commonly used. It consists of a capillary glass tube, called the stem, on the lower end of which a spherical or cylindrical bulb is blown, of such a size that the expansion of the mercury it contains, between the limits within which the thermometer is to be used, exactly fills the stem. When thus filled with mercury, the upper end of the mercury is sealed.

In order that the indications of all thermometers shall be comparable, two fixed points are marked upon their stems. These fixed points are the melting point of ice and the boiling point of water; which, under proper conditions, represent the same temperature everywhere. The lower point is called 32 degrees and the upper point 212 degrees, according to the Fahrenheit scale or zero, and 100 degrees, according to the Centigrade scale, which is used for all scientific purposes. These are, therefore, 180 degrees between the melting point of ice and the boiling point of water, according to the Fahrenheit scale, and only 100 degrees, according to the Centigrade scale. These graduations are either marked on the stem or alongside of it.

In engineering, temperatures are usually measured on the Fahrenheit scale, but sometimes the Centigrade is used. In order to convert degrees, Centigrade into Fahrenheit, multiply by 1.8 and add 32. For instance, to change 40 degrees Cent. into Fahr., multiply 40 by 1.8 and add 32 degrees, which gives 104 degrees. Conversely, to change Fahrenheit into Centigrade, subtract 32 and divide by 1.8.

The process of measuring the amount of heat in a body is called calorimetry and the instruments used are called calorimeters. The amount of heat necessary to raise the temperature of a body is proportional: (1) to the size of the body, and (2) to the temperature rise, the total amount of heat required, therefore, being the product of its mass and temperature change. On comparing different substances, however, it is found that they are heated or cooled differently with the same amount of heat even though their masses be the same. That amount of heat which will raise one pound of water one degree will raise one pound of iron ten degrees or one pound of mercury thirty degrees.

It is, therefore, necessary to agree upon a particular sub-

stance so that the amount of heat required to raise a unit mass through unit temperature be called unity. Such a substance is water. It is readily obtained pure and it requires a greater amount of heat than any other substance to produce in it a given temperature change. A unit of heat is, therefore, defined as the amount of heat required to raise one pound of water one degree and is called a British Thermal Unit.

Since other substances require a less amount of heat to change the temperature one degree, the ratio of this amount to unity is called the specific heat. The specific heat can, therefore, be defined as that fraction of a unit of heat which is required to raise the temperature of unit mass of that substance one degree. The specific heat of various substances is as follows:

Liquids.	
Water	1.0000
Mercury	0.0333
Alcohol	0.7000
Benzine	0.4500
Ether	0.5034
Solids.	
Copper	0.0951
Gold	0.0324
Wrought-iron	0.1138
Cast-iron	0.1298
Steel	0.1170
Lead	0.0314
Zinc	0.0956
Ice	0.5040
Gases.	
Air	0.2375
Oxygen	0.2175
Hydrogen	3.409
Nitrogen	0.2438
Superheated steam	0.4805
Ammonia	0.5080
Salt solution—15 per cent. salt	0.8606

If, therefore, the specific heat of a substance be known, the amount of heat which it contains can be calculated, if it does not change its state. For instance, suppose a copper ball, weighing 10 pounds, is raised from 60 to 132 degrees, how many heat units are required? It is only necessary to multiply the difference in temperature by the weight and specific heat, or $72 \times 10 \times .0951 = 68.47$ heat units.

When heat is applied to a body it generally expands and the amount of expansion for each degree of rise in temperature is quite regular and is called the coefficient of expansion. This coefficient is the amount a body of unit length will expand or contract for each degree of difference in temperature. The coefficients of expansion for a few of the important solids are as follows:

Aluminum	.0000123
Brass—sheet	.0000105
Lead	.0000157
Wrought-iron	.0000064
Cast-iron	.0000055
Copper	.0000088
Steel	.0000065

For liquids and gases, the coefficient of cubic contents per unit rise in temperature is given, rather than linear expansion. A few of these follow:

Air	.002034
Mercury	.000099
Alcohol	.000610
Sulphuric Acid	.000270

There is one important substance that does not always expand upon the application of heat, and that is water. When water at 32 degrees Fahrenheit is heated, it contracts instead of expanding and this continues until the temperature reaches 39.2 degrees, which is the point of minimum volume. Above that temperature the addition of heat causes the water to expand.

Besides change of temperature and change of volume, heat produces change of state. There are three states in which a substance is found: solid, liquid and gaseous. When a solid body is exposed to the heat, not only does its temperature rise and its volume increase, but it liquefies, if it is not previously decomposed. When a liquid body is sufficiently heated, it is vaporized and becomes a gas or vapor. The former is called liquefaction and the latter vaporization. The laws of liquefaction and vaporization are quite important in engineering, as water, which is used extensively, is commonly found in the three states: solid, liquid and gaseous. For solids such as ice, there are two important laws: 1st. Every substance begins to melt at definite point of temperature, which is always the same for the same substance and pressure. 2d. After melting begins, the temperature of the liquid remains constant until the liquefaction process is complete.

In general, solids expand on melting, so that the volume of the liquid is greater and its density less than that of the solid. Water, bismuth, type metal, and cast-iron are exceptions to the rule. Were it not for the fact that ice is lighter than water, all the rivers would be frozen solid in the cold weather.

As a solid may be melted by the addition of heat, so may a liquid be solidified by the subtraction of heat. Therefore, for every liquid there is a definite solidifying point, the temperature of which is constant so long as the solidifying process is in progress. Substances like bismuth and antimony which expand on solidification give sharp castings, while gold, silver and copper, which contract, do not give good castings but must be stamped in a die to get good effect.

Since during the time a solid body is melting or a liquid body is freezing, no change of temperature takes place by the addition or subtraction of heat, it follows that a certain amount of heat is not accompanied by any temperature change. Consequently, this heat energy is stored up in the body as potential energy and is called the latent heat of fusion. The latent heat of liquefaction is the same as the latent heat of fusion except that it is the amount of heat, measured in heat units, which is required to change a solid of unit mass into a liquid under the atmospheric pressure without alteration in temperature.

The following are a few examples showing the melting points of solids and their latent heat of liquefaction in British Chemical Units per pound:

	Melting Point.	Latent Heat.
Ice	32	144.
Beeswax	140	148.
Phosphorus	177	9.06
Sulphur	405	16.86
Tin	426	500.

Still more important than solidification and liquefaction is the vaporization of a body, which is the process of converting

a liquid into vapor. Vaporization may be effected in two ways: by evaporation or by ebullition. Evaporation takes place solely from the surface of a liquid, while ebullition is the production of vapor throughout the mass of the liquid. When liquids produce vapors readily, they are called volatile liquids, as ether or alcohol, and those which do not are called fixed liquids, such as heavy oils or mercury.

A vapor in contact with its liquid is called a saturated vapor, because evaporation of the liquid will continue until the maximum pressure for that temperature is reached. If, however, all the liquid is evaporated and heat is continued to be added, the resultant vapor is called unsaturated or superheated vapor, in which case it follows the laws of a gas.

A superheated vapor may be converted into a saturated vapor by increasing the pressure or by decreasing the temperature required to liquefy a gas is called the critical temvapor may be converted into a liquid. The pressure at which a gas liquefies is called the critical pressure, while the temperature required to liquefy a gass is called the critical temperature.

There are two important laws which relate to the formation of vapor from a liquid. It has been found that for a given pressure (1) every liquid has a definite boiling point and (2) this point remains constant after boiling commences until all the liquid has been vaporized. The following are a few of the boiling points of liquids under atmospheric pressure:

Alcohol	173°	Fahrenheit.
Alcohol, wood	151°	"
Ammonia, liquefied	37.3°	"
Ammonia water	140°	"
Benzine	177°	"
Mercury	670°	"
Naphtha	186°	"
Petroleum, refined	316°	"
Water, pure	212°	"
Saturated brine	225°	"

Since the boiling point depends directly on the pressure, it is evident that the boiling point of a liquid may be raised by increasing the pressure, and lowered by diminishing it.

Heat of Evaporization.—Since a liquid and its vapor may have the same temperature, that heat which is given to the liquid to form vapor is used in doing internal work and is stored up in the vapor. A vapor, therefore, possesses more energy than its liquid. This heat of vaporization is not indicated by the thermometer and is therefore generally called the latent heat of evaporation. At atmospheric pressure, water boils at 212 degrees and its latent heat of evaporation per pound is 966 British Thermal Units. Alcohol boils at 172 degrees under atmospheric pressure and its latent heat is 364 heat units.

Transfer of Heat.—Heat may be transferred in three ways: by conduction, by convection and by radiation. The transfer of heat within a body is called conduction and takes place between adjacent particles. Those substances which transmit heat readily are called good conductors; among which may be classed silver, copper, brass, iron and the metals in general. Bad conductors of heat include wood, glass, liquids and gases. Silver is one of the best conductors of heat and based upon its conductivity, the following values of the metals are given as follows:

Silver	100	Iron	11.9
Copper	773.6	Steel	11.6
Gold	53.2	Lead	8.5
Brass	23.1	Platinum	8.4
Zinc	19.0	Bismuth	1.8

The conductivity of liquids is exceedingly small and that of gases is still less.

While in solids, the heat is transferred from one part of the body to another by conduction, in liquids and gases thus transfer of heat is effected chiefly by convection. For instance, if the water in a boiler be heated at the bottom, the warmer water rises and coming into contact with the colder water, heats it and thus produces a circulation until all the parts are at the same temperature. The convection of gases is very important, since they are such poor conductors of heat. The air in a room in which there is a radiator is heated principally by convection. The third method of the transfer of heat is by radiation. This is caused by the formation of wave motion in the "aether" which pervades all space. Certain bodies have the property of emitting more radiation than other bodies and these bodies also have different properties of absorption. The brighter a substance is, the less radiating power it has. Lampblack is one of the best substances for absorbing heat, since it reflects none of it. The radiating power of various substances compared with lampblack is as follows:

Lampblack	100
Glass	90
Bright lead	19
Silver	12
Clean tin	12
Blackened tin	100
Copper	12
Mercury	20

The radiator in a room should, therefore, not be polished but should be kept dull.

Heat which is molecular energy may be made to do work. The principle of this conversion is quite simple and is affected by some agency like steam in a steam engine, which by its expansion transforms some of its heat into work. It has been found by careful experiments that one British Thermal Unit, which is the amount of heat necessary to raise one pound of water one degree, is equivalent to 778 foot pounds of work. For instance, it has been stated above that a pound of good coal will give out about 14,000 heat units, so that should all the heat be utilized, one pound of coal will equal 10,892,000 foot pounds of work.

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Short Circuits.

EDITOR THE PRACTICAL ENGINEER:

On one occasion, I was in charge of a plant which was installed about 15 years ago and the wiring through the building was in a very bad state and I often had short circuits. The way I used to locate them was this: I unscrewed all the lamps from the circuit affected and put a new fuse in. By commencing to screw the lamps on again, I would positively locate the trouble and if that was during the night time, I would not screw the lamp on where the short circuit was, but would wait to repair it, letting the other ones burn.

Boston, Mass. V. M.

POWER PLANT OF THE MARLBOROUGH-BLENHEIM

The Finest Hotel Plant in Atlantic City, N. J.

The enormous increase in the general wealth of this country and the desire of a large portion of the people in this country to constantly take longer and longer vacations from their busy lives, both summer and winter, has caused the erection of many hotels in the mountains and at the seashore to fill that demand. Some of these vacation resorts are inhabited only in the summer, others have their busiest times in the winter, while still others are so fortunately situated, climatically and geographically, that they have a constant stream of visitors in search of rest, comfort and pleasure throughout the year.

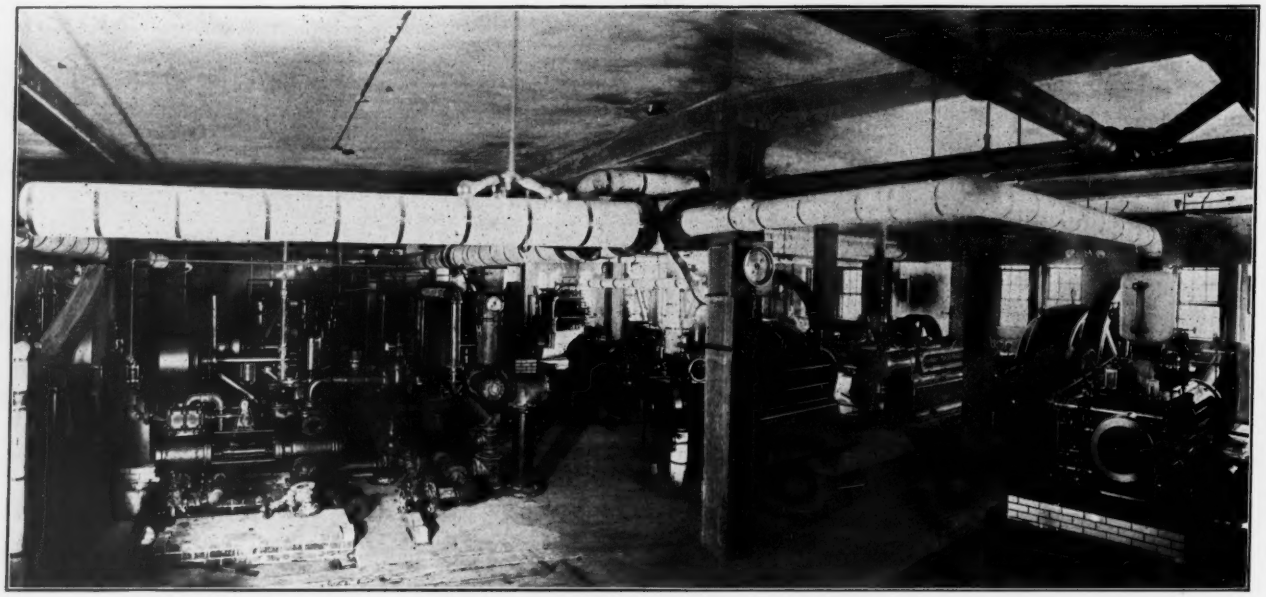
Atlantic City may be classed as belonging to the latter class and, situated as it is directly on the beach of the Atlantic Ocean, in the southeastern part of New Jersey, in comparatively close proximity to New York City, Philadelphia and Baltimore, it has a never-ending rush of visitors, which has caused it to be named the most popular and largest seashore resort in the world.

To satisfy the demands of the various classes of people who come to this resort, thousands of hotels of various sizes and degrees of luxury have been built, among which the Marlborough-Blenheim is the finest and best equipped and it possesses all the features of a modern city hotel. It is of reinforced concrete construction throughout, contains running hot and cold, fresh and sea water in every bath-room, of which there are three hundred, and ice water is supplied from a faucet in every room.

Twenty-one hundred incandescent and arc lamps supply illumination to the building, seven elevators are used to carry the guests between the seven floors, electric appliances, such as curling irons, pressing irons, fans, etc., are furnished when desired and everything is arranged so that the eleven hundred persons which it accommodates may have all the comforts of home-life.

The engine room, which supplies heat, light and power to this building, is situated on the ground floor, as is also the boiler plant. Coal for the plant is brought to the outside of the boiler room by wagons, where it is dumped into a conveyor which carries the coal up and over a number of coal bunkers, which are located in front of the boilers and between them and the engine room. Anthracite buckwheat coal is used for fuel and is hand fired.

There are six 150 horse power return tubular Keeler boilers, three on each side of the stack. They are each equipped with Reliance water columns, one Crosby safety valve and one lever safety valve. Four of the boilers use grates of the Budd type, while two use grates of the Barker type. The stack is built of yellow brick of the Alphonse Custodus type and is six feet in diameter and 126 feet high. The steam is generated at 110 pounds pressure and supplies a 14-inch header, which supplies two 10-inch mains which form a loop around the engine room.

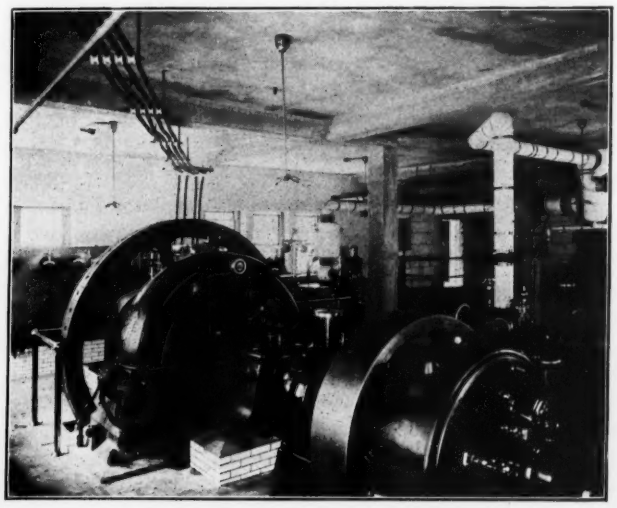


General View of the Engine Room of the Marlborough-Blenheim Hotel, Atlantic City, N. J.

The engine room contains two Allis-Chalmers engines, one Murray engine, two Chandler and Taylor engines, ammonia compressors, feed-water pumps, elevator pumps, vacuum pumps, salt water and well pumps, a fire pump, and other auxiliary apparatus. The steam is supplied to each engine and the steam-driven pumps through the 10-inch main, and at each engine there is a receiver separator for catching any moisture in the steam. The largest engine is an 18″ x 36″ Allis-Chalmers, running at 100 revolutions per minute, which is belted directly from its fly-wheel to a 55 kilowatt generator of the Bullock type. The main shaft is extended and by means of clutches the engine drives pulleys, which in turn drive two

8 x 8 double-acting triplex elevator pumps, one 9 x 10 single-acting well pump, one 8 x 9 single-acting salt water pump, and two 6-ton Brunswick ammonia compressors. This engine is used principally to drive the pumps and ammonia compressors and to carry the electric day load.

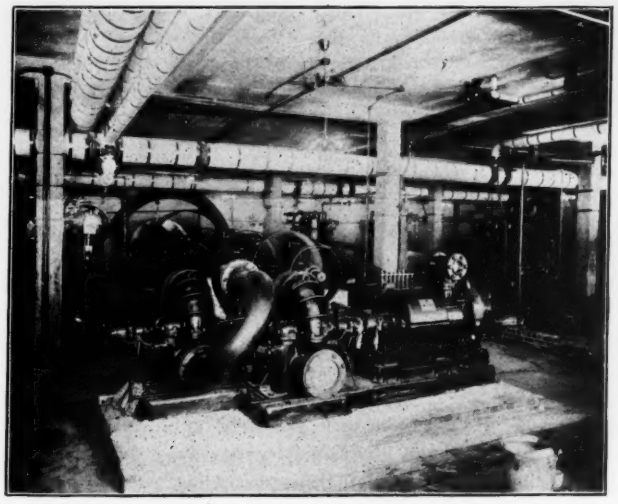
The next largest engine is a 16" x 30" Allis-Chalmers, di-



A Corner of the Engine Room showing 100 K. W. Lighting Unit and Switchboard.

rectly connected to a 100 kilowatt Bullock generator running at 120 revolutions per minute. This unit is used principally for carrying the night electric load. The next size engine is the Murray Corliss, 14" x 36", which drives a 11" x 24" Triumph ammonia compressor at 65 revolutions. Two 12" x 12" Chandler and Taylor engines, each directly connected to 50 kilowatt Westinghouse generators running at 275 revolutions per minute, complete the engine equipment.

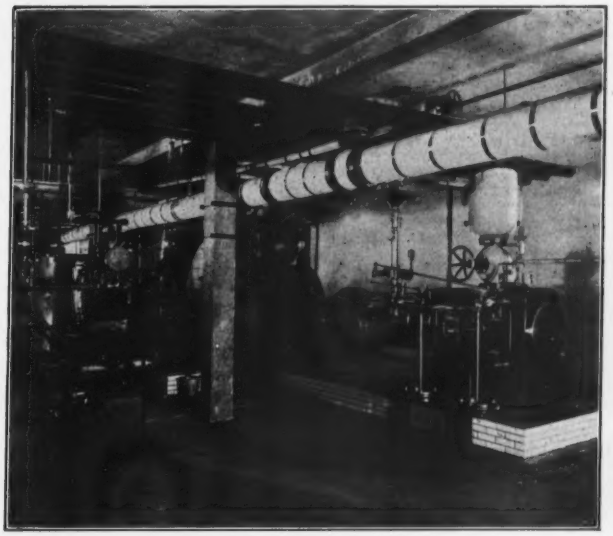
The pump equipment consists of one electric driven 5" x 6"



1200 Gallon DeLaval Turbine Pump at the Marlborough-Blenheim, Atlantic City, N. J.

single-acting triplex Deming pump and one 10 x 7 x 13 Cameron duplex steam pump, both of which are used for boiler feed purposes. Artesian well water is used for boiler feed, which is heated before going into the boilers by a Webster open feed-water heater. Two steam driven pumps, one 12 x 7 x 10 Worthington duplex and one 10 x 6 x 10 McGowen duplex, together with the two 8 x 8 belt-driven double-acting pumps, are used for the elevator service. The elevators are of the Otis hydraulic type, six being of the horizontal type and one of the vertical type, working pressure 130 pounds. The pressure tank for the elevator service is 6 feet in diameter and 21 feet long and the surge tank is rectangular, 6' x 12' x 6'. A steam-driven Deming air compressor is used for maintaining an air cushion in the pressure elevator tank.

A 10 x 7 x 13 single-acting Cameron steam pump and the 9 x 10 single-acting pump connected to the main engine, are used for pumping the artesian well water from the wells into a closed pressure tank. There are two artesian wells, 850 feet deep, which supply water for the boiler feed and for house service. The pressure tank into which the house service water is pumped is located on the engine room floor and is 6 feet in diameter by 20 feet long. Two salt water tanks, each 6 feet in diameter and 10 feet long, are located alongside of the fresh water tank. An 8½" x 8" x 10" single-acting Burham pump is used for pumping salt water from the ocean into these salt water service tanks in connection with an 8" x 9" single-acting



18 x 36 Allis-Chalmers Engine Driving Generator, Pumps and Ammonia Compressors.

triplex pump driven from the belted Allis-Chalmers engine.

There are also three vacuum pumps used for the Warren-Webster heating system, one 8" x 10" x 12" Warren single-acting pump and two 8" x 12" x 12" Marsh single-acting pumps.

For the fire pump, a De Laval turbine pump, directly-connected to a De Laval steam turbine, is used. The speed of the pump is 1180 revolutions and it is capable of pumping 1200 gallons per minute against a lift of 250 feet. The pump is connected to the city mains through an 8-inch supply pipe and is connected to the hose service throughout the inside of the hotel and the sprinkler system on the outside, through an 8-inch discharge pipe.

The refrigerating plant has a total capacity of 52 tons of refrigeration, which is obtained from the 40-ton Triumph compressor connected to the Murray Corliss engine and the two 6-ton Brunswick compressors which are belted from the main Allis-Chalmers engine. The refrigeration is used for making

three tons of ice per day, for cooling the ice water which flows throughout the building and for cooling the refrigerating boxes, of which there are two in the bar, one in help's kitchen, seven in main kitchen, and six in cold storage room. The brine circulation system is used for cooling, two Deeming circulating pumps being used for circulating the brine. The brine pipes and cold storage boxes are insulated by Nonpareil cork, put in by John R. Livezey.

The switchboard is located at one end of the engine room and contains nine panels, four being generator panels, four distributing panels, and one is used for automobile charging. The panels each contain the usual voltmeters, ammeters, knife switches and circuit breakers. The electric load consists of 2100 incandescent and arc lights and 16 motors, of the C and C and Croker Wheeler pattern, of which two are used in laundry for mangles, one for washers and extractors, one for knife-polisher, one for coffee-grinder, one for dough mixer, one on ice cutter, one for boiler feed pump, one on brine pump, one on ice water pump, one for ice cream machine, one for coal conveyor and four for driving ventilators. The voltage used is 115 volts, all the wiring being of the interior conduit design.

Mr. J. W. Frampton is chief engineer of the plant and he has as his assistants two first assistant-engineers, one second assistant, two oilers, two firemen, a house plumber and an elevator engineer.

Examination Questions for Steam Engineers

Questions Should Find Out Whether an Engineer can Apply what He Knows when the Unexpected Happens.

By A. E. Rhodes.

I wonder how many engineers will read the article: "Improper Examination Questions," written by E. S. H., page 18, June issue of The Practical Engineer and then say: "Right! Hit 'em again!" This is one way of looking at the subject and, strange to say, that is the popular way. If it were universally so, however, good men would not apply themselves to the mastery of the theory of their profession.

It seems to me, however, that the inspector can have a great deal to say about his side of the argument, which will depend entirely upon what his training has been. If it has been only technical training, it will perhaps be all book learning supplemented by such practical thoughts as he may have obtained by contact with the practical man. On the other hand, if he is what we ordinarily call a practical man, he will give problems based entirely upon his experience; if he never had other than saw-mill experience, he will talk saw-mill troubles "to beat the band"; if he is a refrigerating man, he will make the electric light man "hot under the collar" and he will try to convince the air compressor man that he does not understand engineering.

Let us imagine a case in my city where Mr. Newton has been appointed an inspector. He is required to examine, on a certain day, ten experienced engineers, ranging in ability from the poorest to the best, or in other words, the average man. Naturally, in such an aggregation, he would have about ten different branches of the steam engineering profession represented and for obvious reasons he must vary his questions to cover the whole ground; a few on electricity, a few on refrigeration, a few on compressed air, etc., and then a few general questions that will apply to every plant, large and small.

Now, I venture to say that every man that takes that examination will say that some one or other question was only a fool catch question and I will venture still further to say that no three men of the ten will call the same question foolish, and further that what one man considers a good question, another man considers a poor one. It all depends upon the view-point. For instance, a man wants to employ a boy to assist the bookkeeper, and the boy must be quick and good at figures or his training is considered poor, or perhaps a printer wants a boy in the office, but unless he is able to spell correctly, his training is considered poor, and so on.

Recently I heard some professors discussing an examination for teachers, as prepared by the superintendent of schools. The general consensus of opinion was that the questions were too theoretical and broad, and not practical. I could not help but feel that one teacher summed up the situation, not only for the teacher but for the engineer, as well, when he said: "Don't you know that I look at it like this: we cover so many grades and branches that the questions must necessarily be broad, general and theoretical. Not to see if we know of the particular thing asked, but as a means of determining the general knowledge of our profession; in other words, to find out what we know and to see if we can apply what we know to finding unknown things and to doing the unexpected things that happen so frequently."

In regard to the question of asking how to cool a hot bearing, I once saw a chunk of ice fastened on the crosshead of a slow moving engine, and because I saw it, would it be a correct answer to say, fasten a piece of ice on a hot bearing? Would it be correct to say, turn on a stream of water? Perhaps it would be better to turn on a stream of water; perhaps either one of the above answers would result in a turn down, depending entirely upon the conditions and how the inspector thinks he would do it.

I would ask what is better than a theoretical indicator card to show if the engineer has a knowledge of the indicator? If I know anything about an inspector's duties, it is primarily to discover if an applicant understands the workings and care of a steam plant and its adjuncts under ordinary conditions and not simply to find out if the engineer knows how to set up an indicator and take cards that apply to some particular isolated case.

I do not consider the problem of the 2000 horse power Corliss compound condensing engine such a poor question as does E. S. H., because it gives the applicant a chance to show "that he knows" by taking supposed conditions and supplying the missing information that will make the question work out in the supposed case, or he can simply say such and such information must be given or the question is incomplete.

I would like to write more on this subject but will stop by suggesting that every engineer, especially the young men, read thoughtfully and carefully the article entitled: "Practical or Theoretical?" written by S. J. S., on page 19, June issue. There is more meat and truth in the last paragraph of that article than is needed for inspiration for a dozen men.

ELEMENTARY ELECTRIC ENGINEERING

The Characteristic Curves of a Dynamo

By Jacob Glogan.

Part I.

A characteristic curve, as its name indicates, is one which shows the characteristics or working of a dynamo. Such a curve can be obtained by plotting corresponding values of amperes and volts of the dynamo at different periods of work or load. These readings are obtained by taking the dynamo to be tested and subjecting it to different loads; and at every change of load taking the simultaneous readings of the voltmeter and ammeter. If some curve paper be obtained, which is paper divided into small, equal parts, and the readings of the ammeter laid along the horizontal lines and the voltmeter readings along the vertical lines, it will give the curve required. The horizontal lines of the curve paper are called the abscissae, and the vertical lines the ordinates. Suppose the range of voltage to be from zero to 110 volts and the current from zero to 10 amperes; we then take the curve paper and lay off the readings as shown in Fig. 1. Suppose the readings were as follows: At zero amperes, 110 volts; at 5 amperes, 100 volts; at 10 amperes, 90 volts; at 15 amperes, 70 volts; at 20 amperes, 30 volts; at 22 amperes, 15 volts; at 10 amperes, 5 volts; and at zero amperes, zero volts; then the curve would look as shown.

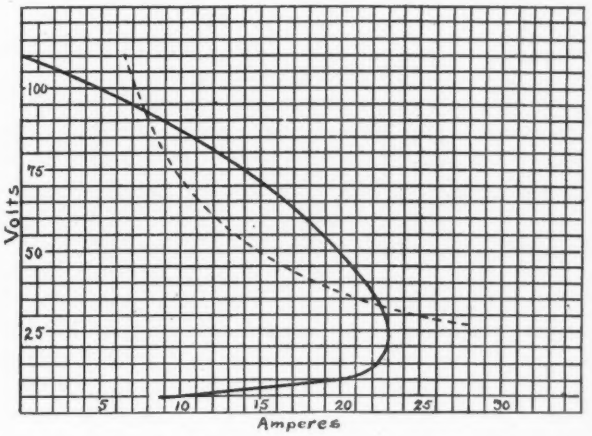
A curve when laid out according to the readings sometimes has a very irregular shape. When this occurs, the average of the readings is taken, which will give a smooth curve. A number of important facts about a dynamo may be brought out by means of its characteristics. These characteristics may be figured out by mathematics but it is more satisfactory to get the results from a practical test of the machine. As a rule these curves explain at a glance the action of the dynamo in nearly the same way as the indicator diagram shows about the steam engine.

One of the facts that an engineer wishes to know is: At what load does the machine work most favorably? As the rating of the dynamo is known, the horse power curve can be inserted on the characteristic curve. This is done as follows: As there are 746 watts in one horse power, any product of volts and amperes giving 746 will equal one horse power, such as, for instance, 10 amperes and 74.6 volts. With this in mind, take the 10 ampere division on Fig. 1 and follow on that line until the line 74.6 volts is reached, when a mark should be made; then going to the 20 ampere line and following along until the line equivalent to 37.3 volts is reached, make another mark and so on until a series of marks has been obtained. Joining these points together, as shown by dotted line, it will be found that it will give a curved line, called the one horse power curve. If a machine of say 10 horse power is being handled, about ten such lines between one and ten horse power can be drawn. The object of these horse power curves can be seen to be of great advantage when the efficiency characteristic of the dynamo is drawn, because at a glance it can be seen whether the dynamo is operating at a high or low efficiency at full or any other load.

There are three characteristic curves of a shunt dynamo to be considered: the external, in which the voltage generated at the terminals of the machine are plotted with the amperes in the external circuit; the internal characteristic, in which the volts generated are plotted with amperes in the shunt field; and the total characteristic, in which the total volts generated are plotted against the total current in the machine, the total voltage being obtained by adding the voltage at the brushes and the drop of potential in the armature, which is equal to the current passing through the armature times the resistance of the armature. The total current is obtained by adding the current passing through the shunt fields to the current in the external circuit.

The internal characteristic rises steeply at first and then bends over as the saturation of the magnets begins. The external characteristic curve is practically a loop. It begins at the maximum and extends horizontally, then it begins to slope, when suddenly it tends to double back and approach its origin.

When the dynamo is started, the outside circuit being open, there is no current flowing through the armature. As soon



as the machine builds up, the armature is only generating current for the field coils, which is very small because the resistance of the field coils is very large. This small current only produces a little drop in the armature, so that the volts generated at the brushes are nearly equal to the total generated by the armature. Hence the current in the field is as great as it can ever become, which makes the field magnetism and also the volts generated, the maximum of the machine. Suppose a number of lamps were connected in parallel on the leads of the machine, the current flows at once and as a result there is a drop in the armature; therefore, there is a little less voltage at the brushes to excite the field coils, which means a slight drop in the volts generated. If more lamps are connected in parallel, the voltage at the terminal will for an instant furnish them with as much current as those already on are receiving, but by Ohm's law, the greater current means increased drop in the armature and consequently a drop in volts generated will follow. With less voltage at the terminals, the total current will diminish a little; consequently, lowering the resistance of the circuit by the addition of more lamps in parallel, lowers the available voltage; for the simple reason that it increases the drop in the armature. As this action goes on, the volts and current drop back simultaneously,

therefore causing the characteristic curve to make the loop and come back to the origin.

Both the saturation curves and the external and armature characteristic will be described in detail in later articles.

ELECTRICITY ON STEAM RAILROADS

The Advent of the Power House for Railroad Practice at last Officially Recognized

At the recent meeting of the American Railway Master Mechanics' Association, held at Atlantic City, the committee on Electricity on Steam Railroads presented some interesting data about the use of electricity, gasoline and gasoline electric motor cars on railroad lines.

The instructions to the committee were to consider and present to the association the relative advantages of the different systems of electric traction now in use as applied to interurban and suburban lines; also, as far as possible, the relative cost of operating such lines by electricity and steam. The committee was also instructed to include in its investigations the different systems of gasoline, gasoline-electric and steam motor cars. The report states that this is almost the first recognition by the Association of other motive power than the steam locomotive. Main line operation was not considered, branch lines, suburban and interurban lines which are feeders to main lines alone being discussed. The committee also understood that the question relates mainly to passenger traffic, as electric traction of freight is carried on to a limited extent only at the present time. Mail, baggage and express are being handled, but these are generally considered in connection with or a part of the passenger traffic.

The class of service considered breaks away from the steam railroad ideas of trains of cars drawn by locomotives, and takes up the individual car or cars, each provided with means of propulsion taking power from some central source. The main business of railroads is to sell transportation, and the only object in considering electric traction is to ascertain whether the cost of carrying passengers can be decreased or the amount of travel be so increased as to provide additional revenue to the road offering it.

In the year 1890, the census report gave for the United States the following mileages of street and suburban railways:

Electric	1,261.97 miles.
Animal	5,661.44 miles.
Cable	488.31 miles.
Steam	711.30 miles.
Total	8,123.02 miles.

In 1902 the mileage was:

Electric	21,907.59	per cent., increase	1636.
Animal	259.10	per cent., decrease	95.4
Cable	240.69	per cent., decrease	50.7
Steam	169.61	per cent., decrease	76.2
Total	22,576.99	per cent., increase	177.9

Statistics are quoted to show that while since 1890 electric traction mileage has increased enormously, yet the greater proportion of the increase was at the expense of the other methods of traction. During this period there was some ephemeral experiments in the use of batteries and of stored compressed air for power purposes on cars, but none of these survive. The above figures also show the backward development in street service of the steam-driven car or "dummy," despite the vast advance in steam railroading proper during these years, and this in itself, is almost a complete argument against the steam car or other types of self-propelled car, except for special situations.

In early electric street railway traction several attempts were made to utilize an electric locomotive, but these were generally abandoned, although it is customary now on some roads to have trail cars attached to leading motor cars. The latest and most advanced practice is to have all cars equipped with motors controlled from the leading car. The development in electric cars has been marked not only by their increase in size and carrying capacity, but also in the size of motors employed. The earlier cars had 15 or 20 horse power equipment, but it was soon found that these were inadequate to properly accelerate loaded cars and now many heavy suburban cars are equipped with four 75 horse power motors each, and in some cars the motor equipment totals 400 horse power. There is thus available for comparison the steam railroad train, consisting of a locomotive with as many cars as the service demands, running at infrequent intervals and covering perhaps 200 miles per day, as against the same road operated with individual electric cars, obtaining power from a general source, running at frequent intervals and fairly equivalent mileage.

The report then describes the advantages of each type of service for each individual traffic problem, but the combination system of electric and steam is not favored except where there is through traffic involved. Few situations, however, will figure out profitably with the combination service, and if electrification is warranted for passenger traffic, a complete change will be desirable.

By far the greater portion of present car equipments are for the use of direct current, but of late alternating current has entered the field and there are some very interesting single-phase operations, the motors employed being capable of running on either direct or alternating current, and by having suitable transformers on the cars, high line voltage may be carried, thus reducing the cost of distribution. Long-distance distribution is best accomplished by alternating current of high voltage, and if direct-current motor equipments are used, the current is transformed at sub-stations at suitable intervals and generally not over ten miles apart. These stations are equipped with transformers for stepping down the voltage, and with rotary converters for changing the current to direct at suitable voltage for the line. Sub-stations on lines employing single-phase machinery have only the transformers, no rotaries being required, and this also reduces the cost of attendance.

The single-phase operation is economical on account of high voltage used on the line, and cheapens very much the cost of distribution from the sub-stations, there being no transformation between the power station and sub-stations. The car equipments, however, are more expensive than direct-cur-

rent apparatus, so that, assuming both to be of equal efficiency, the number of equipments and apparatus required must be considered, and their extra cost weighed as against the low cost of direct-current machinery and more expensive distribution to the line.

The present New Yorw Central-New Haven Railroad situation is an interesting example of the application of these two systems of electric traction, and the ultimate working out of these two great problems will add greatly to the shaping and development of the future of electric traction.

The relative costs of operation with electricity and steam are difficult to state, as there is very little accurate information of value. The results obtained by attempting to draw comparisons from hypothetical roads would depend entirely upon the assumptions which were made. For instance, a set of conditions could be assumed which would show a much lower cost of operation by electricity than by steam; another set could be assumed which would show practically equal cost, and a third set which would show that steam operation would be the most 8
economical. In view of the fact that the assumptions would govern the results, it is believed that information of this nature would not be of value to the association and might lead to erroneous assumptions and misunderstanding. A number of electrifications are under way at the present time, employing various systems of distribution, and a considerable amount of data will no doubt be available in the near future.

Some time prior to the development of electric interurban railways, the steam motor car or dummy, in many cases hauling a trailer, was used to a moderate extent, but at the present time few of these remain. In response to a demand from railroad managers for a motor car to operate on branch lines and special situations, there has been recently a development of motor cars employing gasoline in an internal combustion engine, this engine either directly driving the car or driving a dynamo to generate current to be used for driving motors in the trucks. Some builders interpose batteries between generator and motors to store the energy when it is not all needed for propulsion, and to assist in starting on grades when the generator capacity may be insufficient. There is very great flexibility and convenience in this combination, but it is attained at very considerable expense and complication, and requires unusually skilled attendance not commonly available in railroad service.

The examples of the gasoline engine, electric generator, battery and motor types are the cars of the St. Joseph Valley Traction Company's line, built by F. M. Hicks, and the Strang car that lately made a successful run from New York to Kansas City. The gasoline engine on these types is set to run at a constant speed, and this characteristic is essential for the best economy of the internal combustion engine. The size of the engine used may be proportioned to the average power required for normal operation, and the speed variation and excess of power above normal requirements may be supplied by the battery equipment, which also comes into play for lighting and short movements and would also be available to bring the car in in case of a breakdown of the engine or generator.

The gasoline-electric type not employing batteries is illustrated by the D. & H. car, recently built by the General Electric Company. The generator on this type of car has to be equal to the maximum requirements, and in order to vary the current for the conditions to be met, the field excitation is handled by a separate exciter, chain-driven from the main generator. The controller is semi-automatic and can be set for any predetermined maximum acceleration, and the speed of the car is governed by varying the field strength of the generator. The speed of the engine remains constant after acceleration. This application is very ingenious and effective, and the car has been put into regular service between Schenectady and Saratoga.

The Union Pacific motor car, representing the direct mechanical drive application of gasoline power, is driven by a six-cylinder reversible gasoline engine, with crank shaft at right angles to the length of the car; a sprocket mounted on the same, driving a special chain, transmits the power direct to the driving axle through a second sprocket attached to the axle. The chain easily shows a transmission of power with an efficiency of 97 per cent., which clearly demonstrates that this method of transmission is very close to the maximum efficiency possible. For the initial start of the car, or putting it in motion, a reducing gear is used and, until the car attains a speed of six or seven miles an hour, the economy of this transmission is somewhat reduced; but, as the use of gears is only temporary and lasts only a few seconds, it can almost be left out of consideration.

Interest in the steam car is also being revived, as for example, the Ganz cars imported from Budapest by the Florida East Coast Railways; also the Erie Railroad and the Canadian Pacific are experimenting with a steam car equipped with a Scotch marine type of boiler, using a superheater and oil fuel. It is believed that some one may undertake to make a so-called flash boiler that will be applicable to this service.

It is recognized that the so-called motor car, one carrying its own motive power plant, whether gasoline, gasoline-electric or steam, occupies a distinct field of usefulness especially on branch lines now existing, where travel is light, and on new extensions into unsettled territory. These situations are the distinct field of the motor car, which can be operated for less per car-mile than by regular steam train or electric methods until the volume of business will warrant the regular transportation methods.

The cost per miles for local train service, such as would be encountered on one of the ordinary branch lines west of the Missouri River, the equipment consisting of two cars and a locomotive, would be about 24 cents, including repairs, fuel, oil, labor, cleaning, etc., this for passenger as well as baggage, mail and express service. Electric service equipment, consisting of one car and trailer, figuring that the density of traffic is sufficiently regular to support same seven days in a week, is estimated at about 18 cents a mile.

The gasoline service (mechanical drive only considered), consisting of one car and trailer, with baggage, mail and express service, would cost 15 cents per mile. The latter, of course, would be independent of whether service was six days or seven days per week, the cost simply depending upon the service rendered.

Railroads, therefore, have a choice of the various systems proposed, and a study of the conditions to be met and facilities afforded, both in the way of care and maintenance, as well as the train service proposed, will give the elements by which each situation will have to be studied.

BURNING LOW-GRADE FUEL

Firing with Coal Containing a Large Percentage of Incombustible Matter

In a recent issue of the *Electrical World*, Mr. James F. Hobart, M. E., gives an interesting account of the method of burning low-grade fuel which contains a large percentage of ash, slate and other incombustible matter. The use of the small sizes of anthracite and even coal-yard screenings is becoming more and more prevalent and unless burned properly, their decreased cost will be more than eaten up by the excess of fuel required. In burning cheap grade fuels, more than ordinary care and constant attention are required, not only for the sake of economy, but for the proper steam producing qualities of the boiler. We therefore reprint Mr. Hobart's article in full:

"When called upon to make steam with an inferior or low grade of coal, it will stand the engineer in good need to see what are the possibilities in the direction he must go, and then plan to go as far as possible with the fuel in question.

"Combustion is the term used to designate the chemical combination of two or more heat producing substances, and the kind of combustion that is to be studied by the engineer is the combination of the carbon and hydrogen contained in the fuel with the oxygen of the air which is drawn through the fuel by the chimney or blower draft. Taking this view of the matter, the engineer has to deal directly with only the three elements, oxygen, hydrogen and carbon, and indirectly with whatever incombustible matter may be contained in the fuel and in the air. Roughly speaking, these will be nitrogen in the air, and ash, slate, and other mineral substances contained in the coal; in fact, about anything which goes to make the fuel "low-grade." There is also a percentage of oxygen to be reckoned with as one of the elements contained in some kinds of coal.

"It should be understood by the engineer that carbon and oxygen, or hydrogen and oxygen cannot unite to produce combustion until they have first been heated to what is known as the igniting temperature. For this reason it is necessary to heat the coal with a wood fire to a degree of temperature where the attraction between the two elements is sufficient to permit them to unite or combine. The igniting temperature is fixed, and is below the temperature of the fire as ordinarily maintained in boiler furnaces; hence, once the temperature has been raised to or above the igniting point, combustion will continue as long as oxygen and carbon or hydrogen are supplied, and the temperature will be kept above the igniting point by the combustion itself.

"The temperature of the fire is fixed by the total heat of combustion, and by the products of combustion, and it may be added, by the ash and other impurities contained in the fuel which are directly accounted for in the temperature of the fire and by the excess amount of air which it is necessary to pass through the fire in order to complete combustion of the fuel. When coal is being consumed, it is acted upon by the oxygen, only upon the surface of the pieces or lumps; therefore the burning process must be necessarily very slow, and as the oxygen supply can only be obtained from the air during the act of its passing through the bed of coal upon the grate, it is evident that a considerable amount of air must pass through the grate which does not get a chance to give up its oxygen to the coal. This means that a considerable body of air—usually twice the volume necessary for complete combustion—must be drawn through the incandescent fuel and heated to its temperature, resulting in a considerable loss of heat and a corresponding lower temperature of the fire.

"The engineer must not confuse the total heat of combustion with the temperature of the fire, or the ignition temperature. The latter is the degree of heat necessary to start the union between oxygen and hydrogen or carbon. The degree of heat required is quite low, somewhere below red heat of a piece of iron; and in the case of two gases, the size of the ignition flame may be quite small, as it is only necessary to fire very small portions of the gases, the heat of the burning portions being more than sufficient to ignite adjacent particles of gas, thereby keeping up the process of combustion, and rendering it 'self-supporting' so to speak.

"But in case of coal in large lumps, it is necessary, in order to cause ignition, to heat the coal sufficiently to vaporize the gases contained in the fuel, thus requiring more heat to begin with, and some time—more time the bigger the lumps of coal. Here is a very strong argument in favor of using fine coal, particularly in the lower grades, in order that the necessary oxygen may more quickly come into contact with the carbon and hydrogen of the coal. But in decreasing the size of the fuel lumps, another difficulty is encountered—the small pieces of fuel have correspondingly small air spaces between them, making it very hard to get the necessary air supply through the bed of fuel upon the grate. This means a strong draft, or a forced blast.

"The heat of combustion depends upon the amounts of hydrogen and carbon contained in each pound of the fuel. It has been found by experiment that a pound of carbon, by complete combustion, will give up 14,500 heat units (B.t.u) and one pound of hydrogen gas will yield 62,032 B.t.u. Thus to determine the total heat of combustion of any fuel, it is only necessary to multiply 14,500 and 62,032 by the percentages of carbon and hydrogen respectively, and the sum of the products will be the total heat of combustion of that particular coal. When the fuel contains oxygen, a correction must be made for that substance by taking from the percentage of hydrogen the percentage of oxygen divided by 8, and multiplying 62,032 by the corrected percentage of hydrogen thus obtained.

"The temperature of the fire depends upon the total heat of combustion, and the products of combustion. If there were none of the latter, then the temperature of the fire would be the same as the total heat of combustion, viz.: 4,500 for carbon, and 62,032 degrees for hydrogen; but as each pound of carbon gives off about 3.67 pounds of carbonic acid and 8.94 pounds of nitrogen (from the air used to supply the necessary oxygen) the specific heats of these substances must be taken into account and the temperature of the fire is reduced accordingly. In the above case, it is found that the products of combustion require 2.976 British thermal units, for each degree of tem-

perature these products are raised above the temperature of the fuel and air. As there are available only 14,500 British thermal units to each pound of coal, to begin with, it is evident that the temperature of the fire can never exceed 14,500 ÷ 2.976 = 4,872 degrees.

"It is further evident that if the percentage of products of combustion could be increased in any way, or that the percentage of ash or of incombustible matter should be increased largely, that the temperature of the fire could be reduced so low that ignition would only take place poorly, or not at all, thereby bringing to hand the troubles met with in trying to burn low-grade coal. It will be noted that the temperature of the fire possible in the case noted above is 4,872 degrees. It is not stated that this temperature actually exists in the fire during combustion. The above temperature can never be obtained practically, but a certain temperature cannot be exceeded with the fuel in hand, no matter how much the fire may be forced. It shows that no matter how much coal may be burned on each square foot of grate, a certain temperature cannot be exceeded, although a great deal of heat may be liberated in a given time by burning more coal during that time.

"Indeed, instead of obtaining a high temperature, the fire may be smothered to so low a temperature that it will barely ignite the coal; and, if the rate of combustion be still further cut down by closing the draft, the fire will go out entirely. It is found by a study of the conditions named above, that to burn low-grade coal, the fuel should be reduced in size to pieces easily and quickly heated to the ignition point, in order that the gases may be readily separated from the incombustible matter. From the necessity of using fine coal, the draft or blast must be increased to a considerable extent in order to burn a considerable quantity of coal to each square foot of grate surface, thereby keeping the temperature of the fire as great as possible.

"Theoretically, the fire should be as thin as possible, in order that the air supply may pass through the burning coal with as little resistance as possible. If it were possible to produce an ideal consumption of coal, there would be a coating of fine coal spread evenly over the grates, just three grains deep. The lower layer of fine particles would be giving up the last of their carbon in gaseous form, the next layer would be in full process of distillation, giving up gases freely, and yielding heat units freely. The upper layer of fuel particles would be in process of becoming heated to the igniting point, the more volatile hydrogen products would be passing off and uniting with the atmospheric oxygen, and becoming ready to take the place of the middle layer of fuel particles when another top layer shall have been uniformly and instantly distributed over the theoretical grate of which there was no area taken up by necessary grate bars.

"Under such conditions, inferior coal can be burned as long as it contains enough carbon and oxygen to keep up the fire heat of six hundred or seven hundred degrees necessary for ignition. But a fire which could barely do more than keep itself alive is of little use for steam making, and the engineer must seek for means of getting as hot a fire as possible, in order that a large amount of heat may be available for water evaporation. To do this, an ideal grate which occupies no space would be required, and the lumps of coal reduced to mere points of no appreciable size whatever, in order that they may be heated, give up their gases, and be consumed instantly; and the three layers of coal particles must be continually and instantly superimposed upon each other i norder that the instant combustion of the layers may be steadily maintained.

"Owing to the mechanical conditions involved in the above-noted conditions, there is at present but one way in which the work can be perfectly done, and that is, to pulverize the coal as fine as possible, and blow it into a combustion chamber with a blast of air heated as hot as possible. By this method, only the theoretical quantity of air need be driven in with the fuel, the grate takes up no space, the coal burns instantly, and the three-particle layer business is assured in all its theoretical completeness.

"But this is very cold comfort for the engineer who has an ordinary—and sometimes it is very ordinary—grate which cannot well be changed, and in comes a cargo of coal which almost needs to be drenched with kerosene oil in order to make it burn hot enough to ignite. In such a case, there is no time to make many changes, the boilers must be kept going, and it is up to the engineer to find a way. In order to burn an inferior coal, a forced draft is necessary, and a blower is preferable for the reason that the heat necessary for handling the steam injected with the coal by a steam jet, does not have to be taken care of when a blower is used.

"To obviate the grate difficulty, a heavy air pressure should be used—at least one and five-eighths inch, or one and three-quarters inch water pressure; then the fine coal will not fall through the openings in the grate, for it can't. The pressure of the air is so considerable, that the fine coal will not be able to fall through the grate bar openings, and the diffusion of the air-blast under the coal, on top of the grates will be so great that the coal will burn almost as if suspended in the air the same as when blown into the combustion chamber by the method first mentioned.

"The worst of this method of firing is the extreme care and skill needed in firing. The coal must be distributed 'one grain thick' all over the grate surface, and to do this, and to spread only a very small quantity of coal at a single firing, requires a good deal of hard work as well as skill and patience. But it must be approached if good results are to be obtained with coal half slate or other non-combustible matter. It will be necessary to put in a grinder and reduce the entire quantity of coal to as fine a powder as possible, so as to approximate the conditions of the blowing-in method.

"The firing must be frequent and in very small amounts each time, as noted before; so that when the engineer has arranged a blower to deliver air beneath the grates, and a grinder to pulverize the coal, then he might as well remove the grate bars altogether and use the blowing-in method of firing the pulverized coal.

"In many cases, the above, even, cannot be done when low-grade coal must be burned. In such instances, it is the duty of the engineer to approximate the ideal conditions as closely as possible. The blower must be provided in any event, if low-grade coal must be burned, and the blower should be arranged to deliver under the grate-bars. This method works very well in some instances but it is not desirable where very fine low-grade coal must be burned on a grate perhaps far too coarse for that kind of fuel. The blast must be delivered beneath the grates; then it is not necessary to cut off the air when the furnace doors are opened for firing or for cleaning fires.

"In starting a fire with fine coal, a heavy blast, and a coarse

grate, it will be necessary to put on a thicker layer of coal than will be needed at any subsequent firing, and great care must be taken that no holes open in the layers of coal. Whenever such an opening develops, the fact will at once be known by the appearance of 'forge-flames' which stream up much like the flames on a smith's forge when the fire is being forced, hence the name of the flames in question. When holes begin to develop, as heralded by the 'forge-flames,' take care to fill the openings promptly and thoroughly. Any quantity of air permitted to blow through openings in the coal layers can only result in a waste of coal by requiring a larger amount of heat to warm the surplus air which is blown through the grate without imparting its oxygen to aid in combustion.

"In order that the engineer may more fully comprehend the necessity for close firing with low-grade coal, he should go more fully into the matter of the temperature of the fire, total heat of combustion, and the quantity of air required for burning various qualities of coal.

"The complete combustion of one pound of carbon forms a gaseous compound weighing 3.66 pounds and commonly called carbonic acid, but its chemical name is carbon dioxide. When sufficient air is not supplied to provide the necessary oxygen, another compound is formed, weighing 2.33 pounds, and called carbon oxide, or more exactly speaking, it is carbon monoxide and contains one pound of carbon united by incomplete combustion with 1.33 pounds of oxygen. It is a remarkable fact that the 2.33 pounds of carbon monoxide may afterward be combined with another 1.33 pounds of oxygen, forming the 3.66 pounds of carbonic dioxide, and completing the combustion the same as if the entire quantity of oxygen had been supplied at once.

"Hydrogen forms only one compound with oxygen during combustion. Water is the result of the combination of oxygen and hydrogen, and eight pounds of oxygen are required to consume one pound of hydrogen, forming nine pounds of water. In any fuel ordinarily used for steam making, it may be assumed that the combustible portion is composed entirely of carbon and hydrogen. A small portion of sulphur sometimes is present, but it may be neglected in the calculations. Oxygen, however, must be noted in the calculations when it is present, and account taken of its effect upon the combustion.

"In the air which passes through the grates the percentage of oxygen is 23.195, and that of nitrogen, 76.815. In calculations, it is exact enough to consider the percentages of oxygen as 23, and nitrogen 77. The nitrogen has no effect whatever upon the process of combustion, and its only act is to absorb and waste the amount of heat required to raise it to the temperature of the fire."

The text-books tell that it requires 34.8 pounds of air to ensure complete combustion of hydrogen, and 11.6 pounds of air in order that its oxygen may consume one pound of carbon. The manner in which combustion takes place, or the happenings during the process of combination of the two gases, called combustion, is shown in detail in the following formulas, in all of which the following letters have the same meaning as given below

	Spec. Heat.	Lbs. per Pound Carbon.	Lbs. per Pound Hydrogen.
W = Weight of Air.....	.2375	11.6	34.8
O = Oxygen	.2175	2.66	8.00
CO = Carbon monoxide .	.2479		
CO_2 = Carbon dioxide	.2170		
C = Carbon.			
H = Hydrogen	3.4090		
N = Nitrogen	.2438		
S = Steam, superheated.	.4805		

h = heat of combustion; B. T. U. = British Thermal Units; from 62° = 1,116.6; from 212° = 966.1.

In the process of consuming one pound of carbon, there are added 11.61 pounds of air, making a total weight of 12.61 pounds put in the furnace. During the process the air decomposes into 2.67 pounds of oxygen and 8.94 pounds of nitrogen, which together with the one pound of carbon, still totals 12.61 pounds. Upon completion of the process, the products of combustion will be as follows: 3.67 pounds of carbon dioxide, and the 8.94 pounds of nitrogen which remained inert during the combustion of the carbon. The weights again total 12.61 as before.

The chemists put this whole matter in the form of an equation, so that it may be seen at a glance and comprehended much quicker than if spread out over a half page of paper. The statement is something as follows:

Fuel.	*Combustion.*	*Products.*
1 lbs. C	1 lb. C	3.67 lbs. CO_2
11.61 lbs. Air	2.67 lbs. O	8.94 lbs. N.
	8.94 lbs. N	
12.61	12.61	12.61

If the engineer will secure from the proper government officer or from the mine owner from which his coal supply is purchased, an analysis of the particular coal used, he will find there the percentages of O, C and H contained in that particular coal, and from the data thus secured the engineer can determine the amount of air required for complete combustion of the fuel in question. To this it is found in practice should be added an equal amount to provide the air that escapes giving up its oxygen. He can therefore take measures to admit the necessary air for complete combustion of the fuel under test and observation.

Tangential Pressure on Crank Pin.

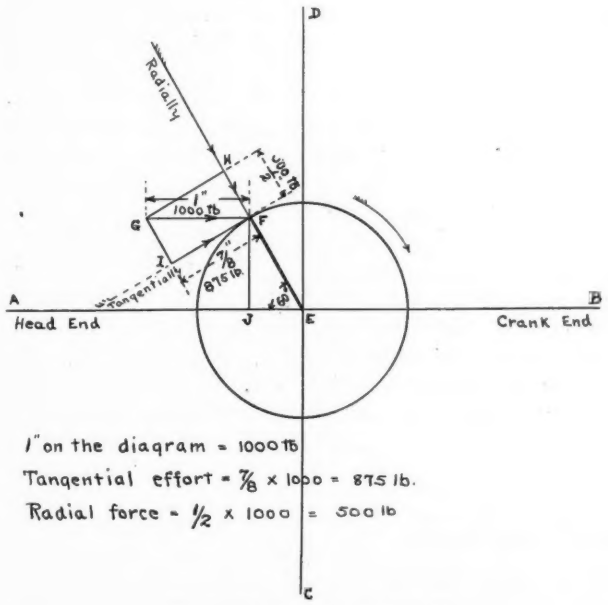
By Chas. J. Mason.

The question was asked the other day: "How can the tangential pressure on a crank pin be calculated?" and as a discussion of this subject may be of interest to the readers of The Practical Engineer, I will present a method in as simple language as possible, so that any reader who desires may employ it himself, without going deeply into the theory of the resolution of forces. We will simply use a diagram, the construction of which will be explained, and from which results may be obtained. While the derivation of a formula, and the underlying principles of the construction of a figure are interesting bits of knowledge to possess, yet it is not absolutely necessary that such be known in order to employ any given formula or figure. So it is with this one.

Let us suppose that we have an engine upon whose piston there is a uniform total pressure or force of 1000 pounds; further, that it is desired to learn what the tangential and radial pressures on the crank pin are, when the crank is at an angle of 60° with the horizontal centre line. We will say that our

engine is a horizontal, and that the crank turns in the direction of the arrow as shown in the accompanying figure. Let us also assume that a distance of 1 inch on the diagram represents a force of 1000 pounds.

First, as to the construction of the figure. As 1 inch is to be equivalent to 1000 pounds, as a matter of convenience, let us choose that figure as the length of the crank in our sketch. Draw the horizontal centre line AB, and at right angles to it, draw the vertical centre line CD. With the intersecting point E as a centre, and a radius of 1 inch, describe the circle as shown. Lay off the line EF, as representing the crank at 60°, from line AE. The point F may be located by dividing the quadrant into three equal parts, F being one-third the distance from where the vertical centre line intersects the circle, and two-thirds the distance from where the horizontal centre line intersects the circle.



Tangential Pressure on Crank Pin

From the point F, draw the line FG, one inch in length, and parellel to the centre line AB. This line represents—to scale—the force of 1000 lbs. acting, in a direction parallel to the horizontal centre line AB, against or upon the crank pin of our imaginary crank. Now, by constructing a parallelogram of forces, we can discover what we set out to find. Produce the line EF to the point H. The point H is at such a distance from F, that a line drawn from G to H will be at right angles to the line EH. Draw IF parallel to GH, and of the same length. Draw GI parallel to HF and also of the same length.

Next, as to the calculations. The line IF represents the tangential force, and it measures 7/8 of an inch, so that upon the adopted scale, 7/8 of 1000 lbs. = 875 lbs. The line HF represents the force in a radial direction, as shown by the arrow, and it measures 1/2 inch; so that 1/2 of 1000 lbs. = 500 lbs. The diagram should be easily understood in connection with the foregoing explanation, and a little study will bring it out. Why the parallelogram of forces reveals what it does is another story, and is only indirectly related to our present subject.

When a scale is made choice of, so that the stated force as represented by a line, is the same as the length of the crank in the diagram, by dropping (see figure) a vertical line, as from F to J, the tangential force may be found for any crank position. In other words, FJ is the same length as IF, and will be the same in length for any position of the crank EF, so long as EF and GF are equal in length.

In the foregoing neither weight of parts nor position has been considered.

Figures About Niagara Power.

In the recent issue of the *Outlook*, Mr. H. W. Buck, an electrical engineer stationed at Niagara, gives some interesting data about the power lost at Niagara. "The total available power of the Falls," he says, "would represent about 3,500,000 horse power. To generate one horse power continuously for a year by a steam engine requires about 13 tons of coal. To generate continuously 3,500,000 horse power by steam would require about 50,000,000 tons of coal per year.

"To generate electric power by steam with the most modern steam plant costs not less than $50 a horse power a year, allowing for fixed charges and operating expenses. Niagara power can be generated and sold in large quantities for $15 a horse power a year, or for $35 a horse power a year less than is possible from the use of coal and the steam engine. From this it will be seen that if all the hydraulic energy of the Falls were utilized for power purposes there would result to the country an annual saving of $35 a horse power for 3,500,000 horse power, or $122,500,000, and in addition there would be an annual saving of 50,000,000 tons coal consumption."

These figures, Mr. Buck says, illustrate what it costs the people of this country to maintain Niagara Falls as a spectacle. They represent the saving to those who would consume the power and not the profit to those who might own power developments. The waste involved in prohibiting the development of Niagara power might be likened to a great conflagration in which 50,000,000 tons of coal were annually consumed. Such a conflagration might be one of the most magnificent sights in the world, and people might come from all parts of the world to view it, but the human race would be justified in using every effort to stop the waste by putting out the fire. "Moreover," he says, "it does not follow that even a very extensive use of the power will mar the beauty of the Falls."

Cleaning Producer Gas.

If producer gas is to be used in gas engines, it is necessary to remove the foreign matter in it or trouble will arise in the engine. There are five methods used for cleaning the gas, as follows: 1. Deflectors, which depend upon the fact that the sudden deflection of the gas carrying foreign matter in suspension, which will result in the precipitation of a part of the foreign matter. 2. Liquid scrubbers, which remove the foreign matter by bringing the gas into contact with a spray, film or body of water. 3. Coolers, which lower the temperature of the gas and thereby precipitate the foreign matter, which can be condensed. 4. Filters, which absorb the impurities in the gas. 5. Rotating scrubbers, which either mix the gas and some liquid, usually water, or which make use of the centrifugal force for removing the impurities.

The
Practical Engineer

DEVOTED TO THE ECONOMICAL GENERATION AND UTILIZATION OF POWER

PUBLISHED ON THE FIRST OF EACH MONTH BY

L. L. RICE

46 North Twelfth Street Philadelphia, Pa.

Correspondence solicited, and paid for upon publication. Short articles descriptive of the small problems met with in daily engineering practice are especially desirable. Illustrations prepared from pencil sketch.

Subscription Price, Fifty Cents a Year in advance to any Post Office, in the United States, Canada, Mexico or United States Possessions. One Dollar a year to other Countries.

Address all communications and make all checks and money orders payable to

The Practical Engineer

46 North Twelfth Street PHILADELPHIA, PA.

The total circulation of The Practical Engineer for the year 1903 was 77,250 copies, an average of 6437 copies per issue. The total circulation for the year 1904 was 132,000 copies, an average of 11,000 copies per issue, The total circulation for 1905 was 182,500 copies, an average of 15,208 copies per issue.

Any Advertiser is invited to examine our Paid Subscription Lists and Post Office Mailing Receipts at any time.

Entered at Philadelphia Post-office as Second-class Matter

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Difficulties of Governing Water Wheels.

The principal difficulty in hydraulic governing is that due to hydraulic inertia. Water moves sluggishly through long and level pipes and its velocity does not change promptly enough for good governing, unless the water ways are especially designed. If a water wheel is at the end of a long penstock, it takes a certain definite time to get that water column under way or checked in response to the movement of the gates. The longer this time constant of the water column, the more difficult it is to get accurate governing, no matter how good the governing mechanism may be. With a variable load, by the time the water is adjusted to meet the new conditions, the load conditions may again change and the governor will be trying to adjust the speed at the new load, while the water acting effectively will be of an amount and velocity sufficient for the old load.

In order to get accurate governing, it is therefore necessary to keep the time constant of the waterways as small as possible, and to accomplish it, the regulating gate should be as near the wheel as possible and the penstock should short and as nearly vertical as possible. The most favorable condition is attained when the wheel is practically located in an open flume. Where long head pipes must be used, governing will always be difficult, but the use of an open vertical standpipe connected with the penstock close to the wheel will aid considerably. The contents of the standpipe serve as a pressure column if the gate is suddenly opened and as a relief valve if the gate suddenly closes. With high heads, such a method is impractical, due to the height of the standpipe, and some other form of relief valve must be used. Impulse wheels with deflecting nozzles are, therefore, used extensively with high heads on account of the ease with which they can be governed.

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Steam Piping Systems.

Several years ago, it was the custom to install duplicate systems of piping, especially in large plants where a shut-down due to any cause would be a serious matter. The increased cost of installation, the greater loss due to increased radiating surface, the complexity of arrangement of the pipes and the increased number of drip pipes required have caused this method to be more or less frowned upon, so that in new power houses, except in occasional instances, the duplicate system of piping is not now being utilized.

In the place of the duplicate or the ring system, the system of sectional subdivision is more often employed. This consists of but one single straight boiler main supported on the boiler room side of the division wall, it being connected to each boiler and engine by a long, easy bend. The valves used are gate valves so arranged that each boiler and engine form one unit. In case of the failure of any section, the valves at each end can be closed, isolating the boiler and engine unit affected, so that the remaining engines may be run by the boilers not cut out.

The use of the automatic boiler cut-off valve which operates automatically if the steam main should burst or if a tube should blow out, tends to make the sectional system still more reliable. The principal objection to the sectional system is that it does not afford any intercommunication of boilers and engines on different sides of the break, but this is more

than counterbalanced by the simplicity of arrangement, smaller number of joints and decreased cost of installation.

Perhaps the principal reason why the sectional system has come into extended use is the increased reliability of all parts of the power plant, especially the generators. In the well-designed power plant where there are four 1000 kilowatt units, it is usual that three of them will be running under full load, while the fourth will remain idle until such times as the peak load occurs. During the several hours of the peak load, the four engines will be running probably at the rated load. Should an accident happen to any part of the sectional system, the part affected can be cut out by the proper valves and the three engines will be sufficient to handle the load. Even if the three engine units are compelled to handle the peak load, they will only be working 33½ per cent. above their rated capacity, which in these days of generator construction is scarcely worthy of passing notice.

Of course, in plants where there are a heterogeneous assortment of engine units, the sectional system cannot be employed to advantage, but in present-day design, everything about the power plant is designed with the view of economy and reliability of operation and in case of accident, so that repairs can be made easily and cheaply. If all the engines are of the same size, there need be less number of parts to keep in stock and since a well-designed system of piping also standarizes as far as possible the lengths of pipes and nipples, a repair to any section can be made in minimum time, by keeping these standard lengths in stock.

It is not usual to find duplicate switchboards or duplicate electric mains from generator to switchboard, so that in the future, it will probably be unusual to find duplicate systems of piping.

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Cooling of Compressed Air.

When any gas, such as air or ammonia, is compressed, the compression is accompanied by a rise in temperature, and unless this heat is abstracted during the process of compression, there is a loss in economy.

In the early days of slow running air compressors, the air was successfully cooled by the injection of a spray of water, but with the introduction of high speeds, some other method has had to be adopted. Naturally, one of the first methods used other than the spray injection, was the water-jacketing of the air cylinders, but owing to short interval within which the compression takes place, the water jacket is more effective in keeping the cylinder cool for good cylinder lubrication and in preventing the temperature from running up too high than it is for actually cooling the compressed air.

There are two conditions under which the compression of air is accomplished. When the heat of compression is removed as fast as generated and the compression proceeds under a uniform temperature, it is called isothermal compression and the compression curve has the form of an equilateral hyperbola. If the isothermal compression of air were entirely practical and if the heat given up to the cooling agent could be applied again to the air during its re-expansion, the result would be a thermodynamic efficiency of 100 per cent. and it is toward the approximate realization of these ideal conditions that the best compressor practice is directed.

In the other condition, called adiabatic compression, during which no heat is abstracted from the air, the temperature of the air rises with the compression, so that since a given weight of air at a given pressure occupies a volume proportional to its temperature, the volumes at all pressures are greater under adiabatic than under isothermal compression, so that there is a waste of energy caused by allowing the heat to remain in the air.

Since the value of isothermal compression is easily recognized, and since neither the water jacketing nor complete cooling inside the cylinder is practical, the air from the compressor is now generally withdrawn from one cylinder before compression has been completed, and allowed to cool thoroughly before being returned to another cylinder for the completion of the compression. This is generally known as two-stage compression with a cooler in between the stages. If the compression required is very high, then more stages are used, allowing the air after each stage to become properly cooled.

For low pressures, however, it is not advisable to use anything but a single stage compressor because the difference between the efficiency of a single and multi-stage compressor is not very great, as the adiabatic loss under low pressure is very small, and the difference between first cost and operating results would not be comparative. Above 100 pounds pressure, the inter-cooled, two-stage compression will be found the best and about 500 pounds pressures, the multi-stage compressor is recommended.

For high altitudes, the total volume of air that must be handled by a compressor is greater than that at sea-level, and the fact that the heating effect of compressing air at high levels is considerably greater than it would be at sea-level, has made the two-stage inter-cooled compressor even more desirable in high level work than under normal conditions.

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Preservation of Condenser Tubes Using Salt Water.

At the midsummer meeting of the American Association for the Advancement of Science, held at Ithaca, N. Y., Mr. W. W. Churchill presented a paper entitled: "The Preservation of Surface Condenser Tubes in Plants Using Salt or Contaminated Water Circulation," which described the method used in the Long Island City power house of the Pennsylvania Railroad Company. Observations had shown that at times the e.m.f. of the rails in the freight yard of the Long Island Railroad was 9 volts above the potential of the river, and that the current due to this voltage caused the destruction of water pipes in the yard. Since the tubes of the condensers were to be made of 60 per cent. copper and 40 per cent. brass, it was feared that the above potential combined with the galvanic e.m.f. of .4 volt would destroy the tubes very rapidly. In order to prevent all electrolytic action, the joints in the piping were insulated from ground connections and the large water connections were lined with glass melted into the surface. A motor-generator of the form used for electroplating was installed to provide current to neutralize any stray currents which might pass through the insulated joints in the supports and connections, and to prevent the galvanic action. The operation of the apparatus has extended over a period of fourteen months, and with the exception of the pitting of about ten tubes, the results have been absolutely satisfactory.

LETTERS FROM ENGINEERS

IN ORDER to make this department of THE PRACTICAL ENGINEER as interesting as possible, a moderate rate will be paid by us for all contributions published under this heading. However, we do not assume responsibility for the ideas or opinions expressed. None need hesitate to contribute because of inability to draw or write well. We will redraw or revise whenever necessary—it is the idea we want. New ways of doing old things, criticisms of accepted theories, and general engine-room experiences are especially solicited.

An Expert's Opinion on Refrigeration.

EDITOR THE PRACTICAL ENGINEER:

In your July issue of THE PRACTICAL ENGINEER, I was interested in reading over your remarks on "Unit of Refrigeration," but on the piping, in which line I have had considerable experience, I have found for a temperature of 32° that 20 to 24 cubic feet are all that should be allowed for one lineal foot of 2" direct expansion pipe. The most up-to-date experience on brine piping has proven that the use of 2" pipe in brine cooling is a useless expense, as 1¼" pipe will give far better results, as the proportion of brine in a pipe to the surface exposed is more uniform and in the experience that I have had, for the temperature of 32°, 15 cubic feet to one foot of 1¼" brine pipe, with brine at 10° is sufficient in every respect, that is, based on the size of the room that you quote, or say, nothing over 15,000 cubic feet. Forty-five cubic feet of space to a foot of 2" direct expansion pipe is too much and they will have trouble doing the work under general conditions.

I have been able to cool a room with brine at 5 to 10°, which we insulated with our Nonpareil Cork, to 32° without any trouble carrying cut meats, with less than 600' of 1¼" brine pipe. There was more pipe put in the room but it had to be shut off, as the temperature went down too quickly. The size of this room was about 13,000 cubic feet. The pipes were placed in a coil loft overhead.

If you allowed 45' of space to a foot of 2" brine pipe, you will have to have an insulation that would lose not more than one unit of heat per degree of difference per sq. ft. of surface in 24 hours and you will find very few people who are willing to buy that kind of insulation.

Phila., Pa. JOHN R. LIVEZEY.

Can a Pump Lift Water 40 Feet?

EDITOR THE PRACTICAL ENGINEER:

In the July issue, on page 22, R. J. tells about a question that was asked him when he applied for a license: "How can water be delivered to a boiler by a duplex boiler feed pump, placed beside the boiler, from a well 40 feet below the surface?" In reference to this, I would say that about 4 years ago a question was brought into our Engineers' Association which asked how high can a pump lift water? Can it lift it 40 feet? and the answer was, "yes." The question was looked up and it was found to be an old question that goes the rounds about every 10 years.

One of the methods of making the pump pump water from a well 40 feet below was to have the tank placed 20 feet above the water in the well, with a check valve in the pipe leading from the tank to the well. When the pump was started and run for some time, the water would be pumped into the tank half-way up. Then the valve on the pipe leading from the tank to the well was closed and another pipe leading from the tank to the atmosphere was opened. The pump then pumped the water from the tank, a lift of only 20 feet.

As the writer saw this question answered some years ago, it was a Spanish tinker who was the first to discover that a pump would lift water 40 feet. The story was as follows:

Having put in a pump and suction pipe of lead and made all connections air tight, he started the pump but could not get any water; so telling his helper to keep the pump going, he went down in the well to find if everything was tight. He could not find any leaks and he "hollered" to his helper and inquired if he was getting any water and the answer came back "no." The tinker got mad, and swearing in Spanish, he hit the suction pipe with his hammer close to the water, which broke a small hole in the pipe and the air rushing in carried some water along to the pump and the helper began to shout that the pump was all right after all.

Of course, the pump was not getting a full supply of water but it was pumping water, and I think if R. J. had read that story he would have answered that question for the inspector. I would like to hear some other answers to that question.

Fall River, Mass. M. H. H.

Would Use Jet Pump for Lifting Water.

EDITOR THE PRACTICAL ENGINEER:

I have here the answer to R. J.'s question in the July number. The question as given by R. J. is only a catch question and it asks only "how can water be delivered to the boiler" and it does not say anything about the lift of the pump. If that were in it, then any engineer ought to know that the Deane pump or any other pump could not lift water 40 feet, but since the lift is left out, there are a great many ways of getting that water, but the way I would get it would be to place a jet pump in the well within a few feet of the water and let it pump the water to a tank on the surface. The feed pump can then draw its water from this tank.

Greenville, O. L. T.

Another View of R. J.'s Question about 40-foot Lift.

EDITOR THE PRACTICAL ENGINEER:

On page 22 of the July number, R. J., of Providence, gives a question which he says was asked him at an examination for a license, which question he gave like this: "How can water be delivered to a boiler by a small Deane duplex boiler feed pump, placed beside the boiler, from a well 40 feet below the surface?" This question, he says, he could not answer. The trouble with R. J. is, he took too much for granted because the fact that the examiner said that the well was 40 feet below the surface, should not be taken as meaning that the distance between the surface of the water in the well was 40 feet, but rather to mean that the distance between the bottom of the well and the pump was 40 feet. The distance from the bottom of the well to the barrel of a pump might be anything from one foot up to 50, 60 or 100 feet, for that matter, but so long as the distance between the surface of the water and centre of pump does not exceed 34 feet, the pump will get water; provided, of course, that the pump is in good condition.

The point that the examiner wished to make was evidently

to find out if the applicant for the license considered it practical to raise water by suction through a vertical distance of 40 feet which, of course, is not possible. If there were ten or more feet of water in the well, then the pump set at the top of the well will deliver water. The remarks of the examiner, that the question was a very simple matter, was based upon my remarks above.

E. Pepperell, Mass. J. A.

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Mr. Kelly Resents Criticism of His Article in Reference to Compounding Dynamos.

EDITOR THE PRACTICAL ENGINEER:

In the July issue of THE PRACTICAL ENGINEER appears a letter by "R. M.," of Rutherford, N. J., in which that gentleman "Questions Mr. Kelly's advice about Compounding Dynamos."

In his letter, Mr. R. M. not only shows that he misapprehends my article in the May issue of THE PRACTICAL ENGINEER, but he has drawn conclusions of his own which demonstrate the fact that he is even incapable of reading a plainly written article, inasmuch as he has misquoted my article in every respect.

Now, before going further, let me say to Mr. R. M. that the articles that I have heretofore prepared for THE PRACTICAL ENGINEER have been carefully prepared from practical, as well as from theoretical observations, and the method of operating compound-wound dynamos, as set forth in my article of the May issue, is the method usually followed in Central station practice. If that article was misleading, which it positively is not, it would not have found a place in the columns of a journal so practical and up-to-date as THE PRACTICAL ENGINEER.

In his letter, Mr. R. M. quotes: "After everything is ready to put the machine in parallel when one machine is taking the load, bring the other machine up to voltage and adjust it about two volts higher than the machine you are going to throw in parallel with." He then says that "this is done so that it will not take its share of the load."

Now, Mr. R. M. is positively wrong, which I will plainly show by a comparison of his quotation in the July issue, and of my quotation, as published in the May issue, which reads thus:

"Let us assume that No. 1 machine is in service, and that it is desired to run No. 2 machine in parallel with it. First, close the equalizer switch (switch 2), and switch 1, which is in the lead that the series field terminal is connected to, and which is of the same polority as the equalizer. Now, with your rheostat, bring the machine up to voltage. It is well to adjust the voltage about two volts higher than the machine you are going to throw in parallel with. Having done this, close the other line switch (switch 3), which will allow the armature of No. 2 machine to take part of the load. The voltage being just a little higher on No. 2 machine, it will probably not take its share of the load, but can be made to do so by increasing the field excitation by means of the rheostat, or, if it takes too much load, decrease the field excitation a little."

Mr. R. M. states in his letter that when he is putting two machines together, he sets the voltage lower on the machine that he is putting in. Now, I would advise Mr. R. M. to discontinue such practice, because if for any reason the voltage on that machine should fall far below that of the other machine, which I assume is in service, at the instant he connects the machine to the bus bars, current from the bus bars would flow into the machine which he is putting in parallel, and under such conditions, would reverse the polarity of same, and run the machine as a motor. Under such conditions, if the machine is shunt wound, the armature coils would possibly not be injured, owing to the fact that the machine would continue to rotate in the same direction as it did when running as a dynamo, but if the machine is compound wound, as I presume the machines are which Mr. R. M. is operating, serious trouble might result, because if the series field should be stronger than the shunt field, the machine would, in case of reversed polarity, necessarily come to a stop and start up in the opposite direction.

Now, let us imagine the machine to be rigidly connected to a powerful driving engine; in trying to reverse its direction of rotation, due to reversed polarity, against the power exerted by the engine, the armature would draw a heavy current, and in the absence of the circuit breaker or fuse to act promptly, in all probability would burn out. Mr. R. M. also runs the risk of bucking his machines from time to time, which might not be serious enough to "burn out" the armature at the moment, but nevertheless, impairs the armature insulation, which, in time, would cause serious trouble.

Now, those are the conditions under which Mr. R. M. is operating his plant, whereas, if he would adjust the voltage about two volts higher on the machine he is throwing in, as stated in my article in the May issue, it would give him time to turn his attention to the rheostat, having thrown his switches in, while the machine is taking part of the load, and also eliminate any liability of serious trouble by reversing the polarity of the machine, as demonstrated above.

Mr. R. M. also asks in his letter: "What does Mr. Kelly mean by increasing the field excitation to bring up the voltage?" Now, it is hardly plausible to think that Mr. R. M. is operating dynamos and does not know the fundamental principles of same. Nevertheless, for R. M.'s particular benefit I will endeavor to explain clearly the principle on which the field excitation of a dynamo is increased.

To begin with, let me state that it is practically known that the ampere turns of an electric magnet are equivalent to the product of the number of turns of wire on the magnet, and the current flowing through same; consequently, in order to increase the ampere turns of an electric magnet it is necessary to either increase the number of turns of wire on the magnet, or the current flowing through the coil. For instance, let us assume that we have a field magnet on which is wound a coil consisting of 100 turns of wire, and that a current of one ampere is flowing through the coil; in this case, the ampere turns are equal to 100; now, if we should decrease the number of turns of wire from 100 turns to one turn, and increase the current from one ampere to 100 amperes, we would still have 100 ampere turns, as in the preceding case.

From what has been stated above, it can clearly be seen that the ampere turns of an electric magnet can be increased in either one of two ways, i. e., by increasing the number of turns of wire on the magnet for a given current, or, by increasing the current flowing through the coil for a given number of turns of wire on the magnet.

In the case of a dynamo, the number of turns of wire on the magnet necessarily remains constant, consequently, in order to increase the ampere turns it is necessary to increase the cur-

rent flowing through the coil; this is practically and conveniently done by cutting resistance out of the shunt field circuit, by adjusting the field rheostat, which allows a larger current to flow through the shunt field coils and thus increases the magnetic lines of force threading through the magnetic field, which induces a higher E. M. F. in the armature conductors and consequently raises the voltage at the brushes. The rheostat is adjusted in this manner in proportion to the load, etc., until finally magnetic saturation sets in, after which the voltage cannot be increased.

Yes, Mr. R. M., this can be done "on the same machine at the same time with the same rheostat."

Now, Mr. R. M., I would suggest that you read over carefully my article on Operating Compound-wound Dynamos in Parallel, read it as it is published in the May issue of THE PRACTICAL ENGINEER, and I presume you will understand it as clearly as its many other readers.

New Orleans, La. A. C. KELLY.

Fun in an Ice Plant.

EDITOR THE PRACTICAL ENGINEER:

I once had an interesting time getting an old run-down ice plant in going shape, or rather, trying to do so. It was a 10-ton plant fitted with a vertical Buffalo machine that seemed to have served its best days. A Worthington duplex feed pump and another of the same type, together with a single-acting pump for circulating the brine, made up the pumping

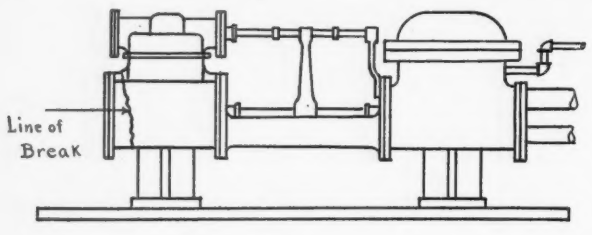


Fig. 1.

outfit of the plant. When I went to the place, the owner and his brother, both men of extensive experience in the business, were doing all that could be done to get things in going shape. They had taken over the plant at the bottom market price, after every one else had failed to get any ice out of it. We were told that, during the preceding three years, no less than ten engineers had tried their luck with the machinery and all of them had given it up as hopeless.

First of all, the machine itself was overhauled from top to bottom and adjusted as well as an old rattle-trap could be made to run. It ran as smooth as a clock for about six hours and then began to let forth grunts and groans too horrible to mention. The cylinder would sound like a dying screech-owl and the crosshead imitated a stamping hammer, while the valves in the ammonia compressor made noises like the ordinary sledge of the blacksmith when it hits on cold iron. By working day and night for two weeks and by using rivers of lubricating oil, we finally succeeded in getting the pound reduced to such reasonable limits that it could not be heard farther than six blocks away from the plant. Then the proprietor began to see visions of a tank full of nice ice and we proceeded to repair the brine-circulating pump.

When the plant had been shut down for the last time, they evidently thought that it would never be used again, so the drains of the pumps and the engine were all left closed. Owing to the fact that considerable water and brine was thus entrapped in the brine pump and frozen during the winter months, we found that the steam end of the pump had broken off its head, as shown in Fig. 1. An order was sent to the blacksmith and the clamp shown in Fig. 2 was made, with a set screw in the end as shown. By this means and a piece of Rainbow sheet packing placed on the break, as indicated in the figures, the parts of the pump were held together and by considerable coaxing and the use of the elixir of oil in abundance, it was finally persuaded to work. Figure 3 shows how the apparatus was assembled.

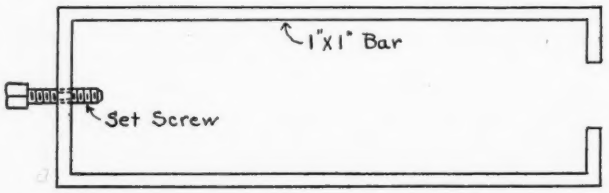


Fig. 2.

It then became necessary to get the other pump in shape to send the cooling water over the condenser coils. This pump gave great hopes at first but these were afterward doomed to be utterly routed, for it was found that the goodwill of the pump was only spasmodic and that it was likely to buck and refuse to go when the water was needed the worst. Then again it would suddenly lose its grip on the suction and start off at a pace more suitable to the dignity of the piston in the cylinder of the "Twentieth Century Limited Express" than in an ordinary modest pump. At these times the discharge pipes which passed to the roof overhead would seem to be the harp strings being played upon by the sledge-hammers of all the muses in the infernal regions. This was the state of affairs one night about 1.00 A. M., when the noise aroused the ice plant expert who slept in the next room as guardian angel over the whole. After trying everything to get the pump working in the desired manner, we went down into the suction well and took up the foot valve, when it was found to be put in exactly up-side-down. Evidently the plant

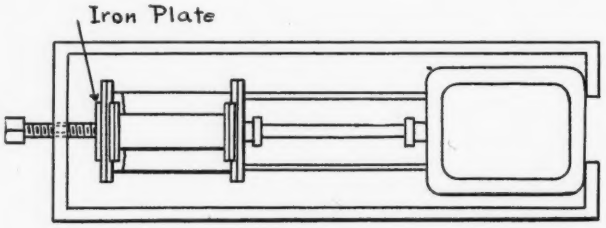


Fig. 3.

had been operated for two years with the valve in this position, but we were so unconservative that we turned it over and found that the pump then worked as smooth as the Elysian Zephyrs on an early spring breeze.

Next after this it was found that the boiler could not keep steam enough to run the machine, although it was considered amply large. All the holes in the pipe and the front and rear connections were plugged up with clay with some improve-

ment but yet there was not enough steam available. Upon looking into the back cleaning door, shown at *A* in Fig. 4, it was found that the combustion chamber had been made with a pit, as shown in the illustration. This was remedied as much as possible by filling it up to the top level of the cleaning door with clay. After this there was considerable improvement in the steaming qualities of the boiler but still there was not steam enough to be had.

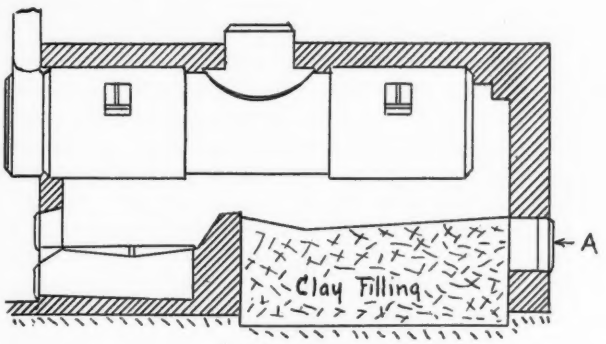


Fig. 4.

A locomotive boiler of 60 horse power capacity was then installed but still there was not steam enough. It was found that the boiler steamed better during the hot days than at night when the draft was good. This was accounted for by the fact that the boiler was in the open unenclosed and the radiation loss was greater at night. Well, after making $5 worth of ice by expending $10 in fuel, for several days, the owner of the plant decided to abandon ship and leave the plant to the mercy of the wind and waves. Upon parting at the station, as I went to another place, he said: "Don't say anything. I know the old thing is on the tallywhack as well as you do, but I think I have secured a buyer."

Chicago, Ill. E. S. H.

Examination Questions for Hoisting Engineers.

EDITOR THE PRACTICAL ENGINEER:

The following questions were asked the candidates for certificates as Hoisting Engineers by the Illinois State Mining Board, at the recent examination, held at Springfield, Ill., and I think they will interest a number of your readers:

1. What are the laws in reference to the duties of a hoisting engineer?

2. What are the laws in reference to persons going into the engine house?

3. What are the laws in reference to the care of engines and boilers?

4. How would you prepare a boiler for cleaning?

5. We wish you to put us in a boiler, to give us 120 horse power, the boiler to be 16 feet long and 6 feet diameter. If a cylinder, say cylinder; if a flue boiler, say flue; if a tubular boiler, say tubular; give number and size of tubes, number of feet of heating surface, grate-bar surface, kind and size of safety valve?

6. We are putting in a pair of compound engines in a mine and we have a steam pressure of 150 lbs. per square inch; our high-pressure cylinder is 20 inches by 28 inches. What size would you have your low-pressure cylinder?

7. We are using 12,000 lbs. of coal to do our hoisting and pumping. We are putting water in the boiler at a temperature of 45° F. How much coal will we use if we put water in the boiler at a temperature of 100° F.?

8. What thickness must the steel be in a cylinder boiler to stand a pressure of 140 lbs. per square inch; the boiler to be 48 inches diameter, allowing 1-6 for safety, tensile strength of steel 60,000 lbs. per square inch?

9. Give the weight of a cylinder boiler 4 feet diameter, 18 feet long and thickness of steel 1.038 of an inch?

10. We have a circular tank full of water, the tank is 12 feet diameter on top and 15 feet at the bottom and is 15 feet deep. The water in the tank is 100° F.; how much coal will it take to evaporate the water into steam?

11. What is an indicated horse power? Give data.

12. Give the signals prescribed by law in this State.

13. With water at a temperature of 40° F., which would you use, a feed pump or an injector?

14. Give the breaking strain of ⅞ steel wire rope.

15. We have a lodge which is 26 feet long, 8.5 feet wide and 7.5 feet deep. The lodge is full of water. How long will it take a 4-inch pump, having a velocity of 100 feet per minute, to empty lodge? We have two 2-inch pipes running full in the lodge at a velocity of 100 feet per minute each. Resistance of pump 10 per cent.

Taylorville, Ill. O. F.

Left-Handed Economy. Precautions with Blow-off Pipes. Bad Piping.

EDITOR THE PRACTICAL ENGINEER:

I saw a case of left-handed economy once, at a plant where the manager disliked to see the various engine and other exhausts blowing around, but would not purchase the necessary heater, traps, etc., to make these various exhausts available for mechanical use. He had his mechanics run about 300 feet of 4-inch pipe and connect all the available exhausts to this, after which a connection was made to the main engines independent condenser discharge, placing a check valve on this discharge line between this connection and the condenser pump.

This, of course, took care of the exhausts without having them blow around, but there was an unseen leakage of dollars and cents that I think would have amazed even the manager himself, if he could have seen a year's results summed up in a convincing manner. This was another instance of the man carefully calking a crack on one side of a barrel, which made a small leak and was dripping slowly, while the bung had fallen out on the other side of the barrel and was wasting quantities of the contents, only the man was unable to see this leak from his point of view.

I once knew of a similar case, where a man expended several thousand dollars installing water wheels, with their attendant canals, flues, etc., and afterward found that because of certain peculiar local conditions, he was unable to get enough water to his wheels to amount to anything, unless he went to considerable additional expense. This he decided not to do, but instructed his manager to use a small amount of water and let the engine, which was coupled to the other end of the main shaft, do the rest. The water available at most times was insufficient to take up the slack in the drive alley and the engine not only carried the load, but also pulled the wheels.

Blowoff pipes generally cause a good deal of trouble unless

they are properly installed in the first place and are then regularly looked after and repaired. They are ofttimes located in such a way that the main line of pipe has to be below the floor line. If this is done properly and the pipes run in a cement lined, brick duct, covered with iron plates, the pipe may be examined easily and will give little trouble from corrosion. On the other hand, if the pipe be buried in earth, particularly if the earth is generally damp at that place, the alternate heating and cooling of the pipe will set up a corrosive action on the outside of the pipe that will very soon fill it with thin places, which will keep breaking loose at unexpected and inopportune times, so that continuous digging and repairing are necessary to keep it in respectable shape.

Another fad of contract pipe men is to run this line in while the boilers are being erected so the erectors can make the connections at the mud drums. As these connections are generally made with flanged angle valves, it leaves the whole line without a flange joint of any kind between the individual boilers, and when the repairs have to be made, the rotten pipes must be cut from the screwed ends of the tees, or Ys and new pieces fitted in with flange union connections. I think the worst job of this sort I ever had to deal with was at a plant where the original designer adopted the iron covers for his pipe conduits and then failed to brick them up, or give them adequate drain connections, so they soon got full of water and stayed so, not only causing trouble from corrosion, but making repairs very difficult. Running a sufficient drain pipe assisted materially in making future repairs, but did not prevent the corrosion alluded to. Another bad thing about the pipe design in this plan was the running of the boiler feed pipes in some of these same ditches, where the failure at once assumed a serious aspect. In doing jobs of this kind it is always well to think once for ourselves and twice for the other fellow who is to come later. We can never tell when we may happen to be "the other fellow" and if the work before us is well done, we will then be in a position to appreciate it very much.

East Greenwich, R. I. L. L. ARNOLD.

Jersey City's New License Law Criticised.

EDITOR THE PRACTICAL ENGINEER:

While I was reading over the new Jersey City license law, recently passed in that city, it struck me that of all the absurd laws that I ever read, that law is the king. I don't want to be too hard in my remarks, but just think of a license law where there is a Board of Examiners consisting of three persons, one to be an engineer with 10 years' experience, which is right, but why should not the other two be engineers also?

It is a rule everywhere that the majority rules, but with the examining board as provided by the Jersey City law, competency is in the minority, with ignorance in the majority, with power to say who shall or who shall not have charge of a steam plant.

It seems to me that this Board should consist of engineers altogether. What does the average person, such as a merchant, know about the safety of boilers? What does anyone know about engineering that is not in the business or who has not been in the business? If all engineers were like myself, Jersey City would not have any engineers until they modified the conditions of their law to suit the above. We have a license law in Ohio but no such one as this.

Dillonvale, Ohio. LICENSED ENGINEER.

Some Experiences at Pokeville.

Hey, Mr. Editur: I suppose ye know old Si Dobbins over tu Pokeville dont ye, he's the one thet runs the engine in the saw mill thar ye know. Come tu think on't, I'd'n know ez ye du know old Si either fer I b'leeve he said he never tuk "THE PRACTICAL ENGINEER," he did nt bleeve in thet kind o'learnin', no how. But how-sum-ever thet may be, he runs the engine over thar tu Pokeville. I s'pose ye know where Pokeville is. Waal if ye dont, mebby ye've hearn tell o' Syracuse, waal Syracuse is near Pokeville, ye know.

Waal Mr. Editur, I seen old Si a while ago an' he says tu me "Bill, what 'n tarnation du you s'pose ails my bilers; thar they set, both of 'em as near alike as two peas, right intu the same settin' with the draft o' both of 'em agoin' intu the same stack, yet the one biler takes easy a third more fuel than tother one with the same load."

I says, "Probbly yer brick work is cracked or suthin, on the one biler so't yer draft leaks an' yer fire dont git air enough."

"No" he says, "Bill thet 'ere brick work is ez solid ez a brick an' taint cracked no where."

"Waal," I says, "mebby she's dirtier'n tother one, suthin' must be the matter er else she'd fire jest ez well an' steam jest ez well as tother one."

"No," old Si says, "she's clean, bekuz the boys they cleaned 'er out good, an' she aint a bit dirtier'n tother one.

Waal Mr. Editur, bime bye I went intu his biler room an' they wuz a usein' of thet biler; the steam trotted up purty high an' the fireman shet off the damper, an' sir, smoke begun a pourin' out frum in under the top o' one o' them 'ere smoke box doors a'hikein'. I jest grabbed old Si by the sleeve o' his jacket, an' I says, "Hey thar!" 'Si, jest look up thar, see that smoke, thar's where yer leak is, thar's where ye lose yer draft.'

Waal old Si, he says, "by gum! I'll be cum-fuddled ef I ever noticed thet afore. Ye see Mr. Editur, thet door wuz warped so bad thet it wouldnt shet tight, an' I told old Si tu take it off o' there an' fix it so 'twould shet tight an' he'd find his trouble tu be at end.

Bime bye I seen old Si agin an' he says tu me, Bill, I've fixed thet 'ere door so't she's tight ez a hot crank pin, an' I kin make a roarin' fire in er, but I'll be blamed if she dont steam 'bout ez hard ez ever, he says. "Bill, I've looked an' looked her over an' over again an' I'll be ding dang daddled ef I kin find a ghost of a reason fer her a'actin' so blamed mean.

Waal, Mr. Editur, at that my curosoty sprinted up quite a bit, fer I allus did hate mos' dredful tu back daown 'bout ennything, even ef I du say it myself by ginger. So I says tu Si 'Ef ye say so I'll come over 'n see if I kin find any thing wrong with 'er next time ye hev her cut out.' 'I've got 'er cut aout naow says Si 'and ye kin come over any time ye've a mind tu and mebby ye kin find it. two heads is better'n one.'

So thet evenin' found me agoin over to Si's. When I got thar I ast Si ef he hed aben intu her sence 'e cut 'er aout, en he said no 'e hed'nt ben intu her in three years, he said he hated most dredful tu git intu her. it made him so narvous and fidgetty like, an he'd jest abaout as soon go daown intu his grave ez to git intu thet biler, &c., &c.

Waal, Mr. Editur, tu cut a long story short, I went intu her myself and tuk a look around. I found she wuz respectably clean, but thar wuz some mud en scale intu her, en thet feed pipe what they pump the watter intu her with, come through the shell on top en' about three feet frum the front

head. et is made of 1½ inch pipe, thar wuz a long thread cut ontu it, en' it wuz screwed through a cast iron block thet wuz riveted tu the shell, then a lock nut wuz screwed ontu the end up tight against the cast iron block, en' then they wuz only 'bout two or three threads left fer to screw the rest o' the business on. Waal, they'd a put on the rest of the business beginnin' with a 1½ inch sleeve coupling, en' it was right there, Mr. Editur, whar the trouble was. the ends of them feed pipes wuz purty well stopped up with mud en' scale so it needed quite a lot of pressure tu force the watter through, and although the coupling hung up thar yit, the watter hed cut channels around, here en' there, right intu them threads until there was a lot of streams en' a spray of watter all the time right intu his steam space.

Waal I seen old Si agin tuday en' I ast 'im how 'es gittin along, en' he looked happy en' said 'O, tollerbly well, how's yerself.

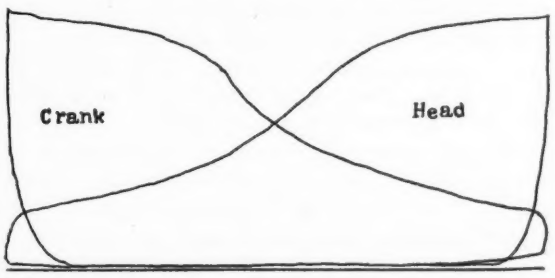
Yours truly,

"Bill."

Card from an Old Buckeye Engine.

EDITOR THE PRACTICAL ENGINEER:

I enclose herewith a card from a 14 x 28 Buckeye engine which has been in constant service for 17 years, day and night A test recently showed this engine developing the load as shown by the card, with a steam consumption of 28 pounds per horse power per hour. This engine has given perfect satisfaction since it was installed and the card is an example of everyday performance, except that heavier loads are carried at times. The horse power of the cards is 135, the speed of the engine being 115 revolutions per minute.



Card from a Buckeye Engine which has been in constant service 17 years.

Princeton, Ind. C. B. RISLEY.

Rules for the Care and Operation of Motors.

One of our readers has sent us two cards which are issued by the Narragansett Electric Lighting Co., of Providence, R. I., for the instruction of all of their customers using motors. These cards are to be hung near the motors and they contain the necessary rules for their care and operation; which we reprint below.

DIRECT-CURRENT MOTORS.

To Start Motor.

a. Be sure that the rheostat arm is in "off" position. *b.* Close the main switch. *c.* Start the motor by moving the rheostat arm slowly over the button points until arm is held in place by the magnet, or rests on the last point.

To Stop Motor.

a. Open the main switch. *b.* If an automatic rheostat, see that the arm flies back to the "off" position by the time the motor is fully stopped.

Brushes.

To prevent sparking, the brushes must be properly set and kept in good order. Resurface them in position with fine sandpaper, drawing it between the end of the brush and the commutator in the direction of rotation. Remove and wipe the brushes clean after 20 hours' run. Set the springs as lightly as will secure sparkless running. Brushes on same stud must be exactly in line. Different sets must be exactly spaced around the commutator.

Commutator.

The surface of the commutator must be kept clean and smooth; if roughened, remove the belt and smooth with No. oo sandpaper moistened with vaseline. Do not use emery cloth. Clean the brushes after sandpapering. If the commutator is badly worn, have it trued with a tool. Clean the commutator daily, then moisten with a least bit of vaseline on a piece of felt or flannel. If the commutator continues to spark badly, send for a reliable electrician to repair it.

Fuses.

On 500 volts do not fuse higher than two amperes to one horse power, if protection of the armature is desired.

ALTERNATING-CURRENT MOTORS.

To Start Motor.

a. If of the internal armature resistance type, be sure that the sliding brushes of the resistance are as far out as they will go. If of the compensator type, be sure that the compensator is set in the "off" position. *b.* Close the main switch. *c.* Start motors of the internal armature resistance type by moving the armature resistance switch in, step by step, taking about 15 seconds to close the switch to the limit of motion. Start motors of the compensator type by throwing the compensator switch to the starting position, and when the motor comes up to speed, throw the switch to the running position.

To Stop Motor.

a. Open the main switch. *b.* If of the internal armature resistance type, draw the armature resistance switch out as far as it will go. If of the compensator type, throw the compensator switch to "off" position.

Brushes.

If of the internal armature resistance type, see that the brushes are always free to make smooth and even pressure on the stationary contacts.

Fuses.

On 500 volts do not fuse higher than 1½ amperes to one horse power, if protection of the motor is desired.

Oil.

Use only best grade of thin lubricating oil. Never fill the oil wells nearer than ¼ in. of overflow. Never let the oil get below ½ in. from top. Renew the oil from time to time when the bearings show a tendency to heat up. Be sure that the oil rings revolve when the motor is in operation.

Belts.

On pulleys less than six inches in diameter, use only the best single belting, very pliable. The belt should be made endless; never put a laced belt on an electric motor. Put the hair side of the belt on the pulley so that the outside of the lap trails.

QUESTIONS and ANSWERS

THE editor will be glad to receive from the readers of THE PRACTICAL ENGINEER, such questions relating to engineering subjects, as may, from time to time, occur to them. All questions and answers should be addressed to the editor and accompanied by the name and address of the writer, which will not be published, however, unless especially desired. It is the intention that questions shall be answered by the readers, and even though the editor may, from time to time, publish answers and questions, he especially desires the readers in such cases to contribute any further information, in connection with the points raised, that they may consider of interest. All questions and answers received by the editor will be published, as far as practicable, but he reserves the right of editing or rejecting any communication.

Thinks Readers Should Answer Questions.

EDITOR THE PRACTICAL ENGINEER:

I have been a reader of your paper but a short time and I find it all that it is claimed to be, a good practical paper for practical men. If I may be allowed to make a suggestion, I think it might perhaps be made better if the readers are allowed to answer the questions before the editor does as I have always found that the boys are more interested in those questions than in anything else. I would like to hear what some other readers have to say about it. In reference to this, here are a few questions which some readers might want to answer.

1. At a boiler test it was found that 11,000 B. T. U were used to evaporate 7 pounds of water. What is the efficiency of the boiler and explain how you find it?

2. Make practical diagrams of a condensing engine, 85 pounds boiler pressure, 26-inches vacuum with cut-off ¼, ½ and ¾ stroke.

3. What area of grate would you put under a boiler 72 inches diameter, 20 feet long, flues of the ordinary size and number?

4. What size safety valve would you put on a tubular boiler?

5. What is the maximum lift of a safety valve?

6. At what pressure would you set the safety valve of your boiler?

7. Name four reasons why shaking grates are superior to common grates.

8. Give four reasons why Corliss valve gears are preferred to other valve motions.

9. Why does bituminous coal make more smoke than anthracite coal?

10. What difference is there between cylinder oil and machine oil?

11. Name 5 things that will cripple a heating plant.

Chicago, Ill. F. L.

Wet and Dry Vacuum Pump.

EDITOR THE PRACTICAL ENGINEER:

As I have been a reader of your paper for some time, I would like you to answer this question. I wish to know the uses of both the wet and dry vacuum pump.

Nebraska City, Nebr. A. S.

The dry vacuum pump is used principally with surface condensers in which a high vacuum must be maintained and is so named principally on account of the fact that it handles only air or vapor. When the steam in a surface condenser strikes the cool walls of the condensing tubes, it is condensed and this water of condensation is handled by a wet vacuum pump. As there is always some air or vapor which comes from the surface of water in a vacuum, the top of the condenser is likely to become filled with this vapor and to better enable the vacuum to be maintained by the perfect contraction of steam into water, the dry vacuum pump is used. It is generally connected to the top of the condenser and the gases are made to pass through an air cooler before they are handled by the dry vacuum pump. The wet vacuum pump is often called the condensation-water or hot-well pump and need only have a capacity to properly handle this water.—[Ed.]

Horse Power of Belts. Batteries in Series and Parallel. Increasing Temperature of Feed Water.

EDITOR THE PRACTICAL ENGINEER:

Kindly answer the following questions:

1. Please give me a rule for finding the diameter of a horizontal white pine timber supported at both ends and loaded in the middle with a weight of 26,759 pounds, the distance between supports being 14 feet?

2. How much more horse power can a double belt transmit than a single belt?

3. If the speed of a belt is known, is that all that is necessary to get the horse power that it will transmit?

4. A double belt is 28 inches wide and runs at a speed of 2000 feet per minute; what horse power will it transmit?

5. A battery cell has an electro-motive force of 1.5 volts and a resistance of 0.8; the circuit has a resistance of 1.1 Ohms. Which will give the greater current, 40 cells in series or 40 cells in parallel? What is the resistance in each case and what is the electro-motive force and current?

6. If the feed water is 56 degrees and is changed to steam at 132 pounds gauge, what per cent. is gained by raising the temperature of the feed to 223 degrees?

Warrensburg, Mo. A. S. E.

1. For a circular beam supported at the ends and loaded at the middle, the following formula is used:

$$10\ P = \frac{.39Rd^3}{l}$$

in which 10 = Factor of Safety, P = load in pounds, R = modulus of rupture, which for white pine is 12,500, d = diameter in inches and l = length of span in inches. Solving the problem for d gives the diameter in the above problem as 20.9 inches. If the factor of safety be taken as six instead of ten, the diameter would be 17.8 inches.

2. Some engineers say that a double belt can transmit twice as much power as a single belt, although the best practice usually allows 1.5 times as much.

3. The speed and width of the belt must be known before the horse power can be calculated.

4. The formula for finding the width of a double belt is as follows:

$$H.\ P. = \frac{wv}{550}$$

in which w = width of belt in inches and v = velocity in feet per minute. Substituting the values of question 4 in the above

formula, it will be found that the belt will transmit about 102 horse power.

5. Forty cells connected in series will have an electro-motive force of 60 volts. The internal resistance of the 40 cells will be 32 Ohms, therefore, the current will be $40 \div (32 + 1.1) = 40 \div 33.1 = 1.208$ amperes.

If 40 cells are connected in parallel, the voltage of all the cells cannot be greater than one cell or 1.5 volts. The internal resistance of the battery is equal to the internal resistance of one cell divided by the number of cells or $0.8 \div 40 = .02$ Ohms. Therefore, the current will be $1.5 \div (.02 + 1.1) = 1.5 \div 1.12 = 1.34$ amperes.

Forty cells connected in parallel will therefore give the most current; the current with the series arrangement being 1.208 amperes and the current with the parallel arrangement 1.34 amperes. The total resistance with the series arrangement is 33.1 Ohms and with the parallel arrangement 1.12 Ohms.

6. The total heat above 32 degrees in one pound of steam at a gauge pressure of 132 pounds is 1190.7 heat units and since the feed water is 56 degrees, the total heat required is 1166.7 heat units. If, however, the feed temperature is 223 degrees, only 999.7 heat units are required. This is a saving of 14.3 per cent. over the higher figure.—[Ed.]

Wattless Current. Copper for Three-Wire Systems. Alternating Current Voltage.

EDITOR THE PRACTICAL ENGINEER:

Will you please answer the following questions through the columns of your valuable paper:

1. What is a wattless current and how is it caused?

2. Explain why only ⅜ of the copper necessary for the two-wire system is necessary for the three-wire system.

3. If a 60-cycle alternator is connected to a circuit that has an inductance of .08 Henries and a resistance of 15 Ohms, what electro-motive force must be supplied by the alternator to force a current of 15 amperes through the circuit?

Shelburne, Canada. S. G. H.

1. Whenever the phase difference, whether lag or lead, is very large, the current, being out of step with the volts, is almost wattless. This is the case with currents flowing through a choking coil or into a condenser, if the resistances are small. If the current and volts are out of step 90 degrees, the current is exactly wattless.

2. In a three-wire system, two dynamos are connected in series, so that if the voltage of each machine is 110 volts, the voltage across the outside terminals of the machine would be 220 volts. A third wire is used, called the neutral wire, which connects with the junction of the plus and minus brushes of the dynamos. The load requiring 110 volts is always connected between one of the outside wires and the neutral wire.

If the load on each side of a three-wire circuit is the same, the neutral wire can be made very small, but in no case is it possible to exactly balance the load. If it were possible to exactly balance the load in every respect, then a three-wire circuit would feed as many lamps as a two-wire circuit with only one-fourth the weight of wire. In theory, the neutral wire needs to be only large enough to convey the amount of current which is out of balance, but in practice a large margin of safety is allowed, so that the size of the neutral wire ranges about one-third to one-half the cross-section of the outside lines in large circuits. Since the two outside wires of a three-wire system only require one-fourth the weight of copper in a two-wire system and since the neutral wire requires about one-half of the cross section of the outside wires, which is equivalent to about ⅛ of the size of a two-wire circuit, therefore the total weight of wire required by a three-wire system is approximately ⅜ of the wire required by a two-wire circuit carrying the same load.

3. The relation between volts, current, resistance, frequency and induction is shown by the formula:

$$V = C \sqrt{R^2 + (6.28\ n\ L)^2}$$

in which V = volts required, C = current flowing through circuits, R = resistance, n = frequency, and L = inductance. Substituting the proper values, the equation becomes:

$$V = 15 \sqrt{15^2 + (6.28 \times 60 \times .08)^2}$$
$$= 15 \sqrt{225 + 908.4}$$
$$= 15 \times 33.6 = 504 \text{ volts}$$

which is the electro-motive force required.—[Ed.]

Pump Capacity. Area and Circumference of Manhole. Horse Power of Belts.

EDITOR THE PRACTICAL ENGINEER:

In your next issue, will you kindly give answers to the following questions?

1. How many gallons per hour would be handled by a pump 3″ x 8″, running 60 strokes per minute, supposing it to be ¾ full each stroke; also what horse power of boiler is this pump capable of supplying?

2. What would be the circumference and area of a manhole, the large diameter of which is 15 inches and the small diameter 10½ inches?

3. If a one-inch single belt running 800 feet per minute transmits one horse power, what would a 6-inch double belt transmit, running at the same speed?

I may say that there has been some difference of opinion among some men here regarding these questions and the correct answers thereto and we have decided to leave it to you to decide.

Toronto, Canada. E. N. G.

1. The volume of a pump cylinder 3″ diameter and 8″ stroke equals 56.5488 cubic inches. Supposing it to be only ¾ full each stroke, this gives 42.4116 cubic inches of water pumped each stroke, and since the pump makes 60 strokes per minute, the amount of water pumped each hour equals 152681.76 cubic inches. As there are 231 cubic inches in a gallon, the pump is capable of pumping 665.28 gallons per hour, or 5541.78 pounds, if the feed water is about 60 degrees. As a boiler horse power is equivalent to the evaporation of 30 pounds of water from a feed water temperature of 100 degrees into steam at 70 pounds pressure, the pump should be capable of supplying 184.7 horse power of boiler.

2. Since the manhole is in the form of an ellipse, the circumference can be found from the approximate formula, $3.1416 \sqrt{(D^2 + d^2)} \div 2$, in which D and d are the two diameters. Substituting the values for D and d, the formula becomes $3.1416 \sqrt{(15^2 + 10.5^2)} \div 2$, which when worked out, gives 40.68 inches for the circumference. This value is accurate enough for all practical purposes, but if it is required to be found exactly, the equation of the ellipse must be found and the length of the circumference found from the curve by integral calculus. The area of the manhole can be obtained

from the formula, $.7854(D \times d)$, which equals $.7854(15 \times 10.5) = 123.7$ square inches.

3. A 6-inch single belt running at 800 revolutions per minute would transmit 6 horse power, but since it is a double belt and a double belt will carry 1.5 times as much load as a single belt, the 6-inch double belt should transmit 9 horse power.—[Ed.]

Setting Piston Valves. The Action of Steam in a Compound Westinghouse Engine.

EDITOR THE PRACTICAL ENGINEER:

Will you kindly answer me the following questions:

1. How do you set a piston valve on a piston valve steam engine?

2. How does the steam work in a Westinghouse compound engine?

Cambridge, Mass. F. H. L.

1. With the single piston valve, steam is admitted at the centre of the valve, or just the reverse of a plain slide valve engine, so that the eccentric must be moved in the opposite direction to which the engine is to run when setting the valve.

If there are no marks on the valve seat or valve stem, the first step in setting the valve would be to take off the valve covers and take out the valve to see that it is in good condition and to get the dimensions of it. Then make a thin sheet steel gauge equal in length to the length of the valve face plus the lead it is desired to give the valve. The shape of this gauge can be made as shown in Fig. 1. Replace the valve in the chest and connect it to the valve stem. The eccentric should then be turned from one extreme position to the other to see that the valve opens the ports an equal amount on both ends. If there is an unequal opening of the ports, the eccentric rod should be shortened or lengthened until the valve has an equal movement. The eccentric should then be moved to the extreme position farthest from the cylinder. Then place the gauge against the edge of the port and with a scriber mark a fine line on the seat as shown in Fig. 2 at *a*. Remove the gauge and turn the eccentric in the same direction the engine is to run until the end of the valve just comes even with the line *a*. Secure the eccentric to the shaft and turn the crank in the direction it is to run until the eccentric reaches the extreme position nearest the cylinder. The gauge is now placed against the edge of the opposite port and a fine line drawn on the seat

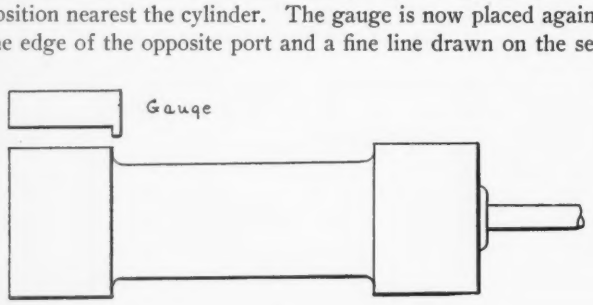


Fig. 1.

in the same manner as shown in Fig. 2. Then turn the crank to its dead centre farthest from the cylinder when the end of the valve should just reach the line on the seat. If the end of the valve does not come even with the line, the eccentric should be turned so as to move the valve one-half of the distance between the line and end of the valve. The valve will then open both ports to the proper lead when the crank is passing both centres.

When it is undesirable to remove the valve chest covers each time the valve is set, the valve rods should be marked and trammed and by carefully preserving the gauges, any inaccuracy in the valve motion can be found easily.

2. The Westinghouse engine as usually built consists of two single-acting cylinders with the cranks 180 degrees apart. The

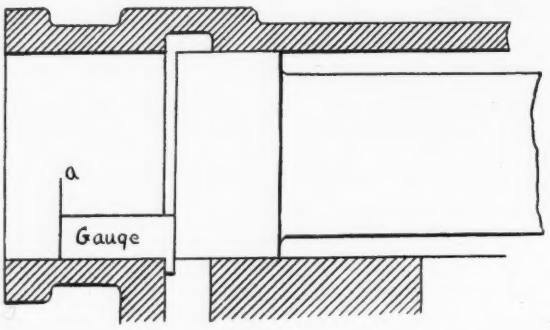


Fig. 2.

steam is admitted into the head end of each cylinder, where after doing its work it is exhausted.

In the compound engine, however, the steam after entering the head end of the high-pressure cylinder is made to complete its work in the head end of the low-pressure cylinder, there being two single-acting cylinders with cranks 180 degrees apart, the pistons in all engines of the Westinghouse type being of the trunk pattern.

The steam distribution can be explained by referring to the accompanying diagrams. One piston valve is used for distributing the steam in both cylinders. Fig. 3 shows the high-pressure piston about to begin its downward stroke and the low-pressure piston is just starting on its return stroke. The valve is moving toward the left and has travelled from mid-position just the amount of the steam lap and lead, and is beginning to uncover the port leading from the steam space S. The right hand end of the valve, having no lap, has already uncovered a part of the port leading to the low-pressure cylinder. The valve travelling toward the left admits steam from the steam space S into the space around the neck of the valve, and thence through the port into the high-pressure cylinder, driving the high-pressure cylinder downward; at the same time the crank is forcing the low-pressure piston upward, and the exhaust is passing through the port into the right hand end of the steam chest and thence through the passages shown into the exhaust chamber E, and away through the exhaust pipe connecting with E. When a portion of the revolution has been completed—depending upon the position of the governor—the valve has gone to the limit of its travel to the left and returned to a point where it just covers the admission port, cutting off the steam, and is travelling to the right.

The exhaust end of the valve, on account of not having lap, has not yet covered the port, the several parts being in the position shown in Fig. 4.

Referring to the theoretical indicator diagram, Fig. 5, an indicator attached to the high-pressure cylinder would have described the admission line *a b*, while an indicator on the low-pressure cylinder would have described a corresponding

portion of the exhaust line *f g*. As the pistons continue their strokes the steam in the high-pressure cylinder and the space around the neck of the valve expands, and the valve, travelling toward the right, closes the port leading to the low-pressure cylinder before the completion of the upward stroke of the

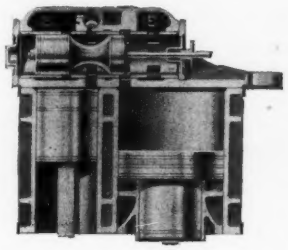


Fig. 3.

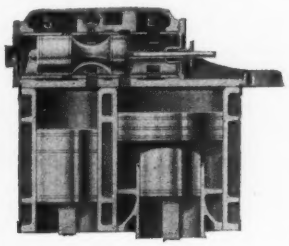


Fig. 4,

low-pressure piston, compressing enough of the exhaust to fill the clearance spaces.

Referring again to the theoretical card, during this period the indicator on the high-pressure cylinder would have drawn the expansion curve *b c*, and the indicator on the low-pressure cylinder would have completed the exhaust line *f g*, and drawn the compression curve *g c*.

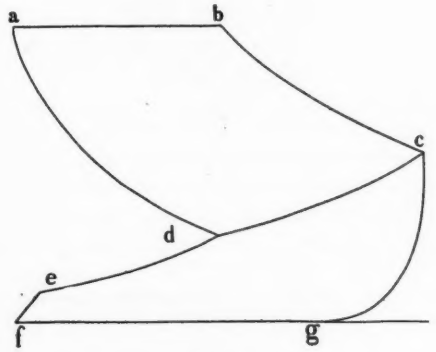


Fig. 5.

On the completion of one-half of the revolution, the valve and pistons occupy the positions shown in Fig. 6. The low-pressure piston is commencing its downward stroke, and the high-pressure piston is starting on its return stroke. The valve is travelling toward the right, and beginning to uncover the port leading to the low-pressure cylinder, establishing communication between the two cylinders through the space around the neck of the valve. As the pistons continue their

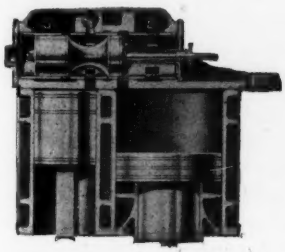


Fig. 6.

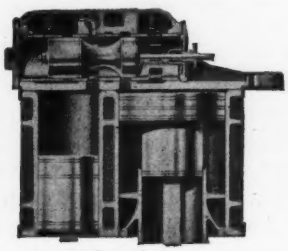


Fig. 7.

travel the steam is exhausted from the high-pressure cylinder into the low-pressure cylinder, until the valve has gone to the limit of its travel to the right, and come back again so as to cover the low-pressure port and interrupt communication between the cylinders. During this period an indicator on the high-pressure cylinder would describe the exhaust line *c d* on the theoretical card, and were there no port friction the low-pressure admission line would coincide with *c d*. The steam expands during this part of the cycle, as shown by the drop of pressure from *c* to *d*, by reason of the greater area of the low-pressure piston.

The valve and pistons are now in the position shown in Fig. 7, the valve moving toward the left, and the pistons continuing their respective strokes. From this point to the completion of the revolution the steam remaining in the high-pressure cylinder and space around the neck of the valve is compressed up to or near initial pressure, while the steam in the low-pressure cylinder continues expanding until just before the end of the stroke, when the right hand end of the valve uncovers the low-pressure port for release. During this period indicators on both cylinders would draw lines corresponding respectively to *d a* and *d e f* on the theoretical card, and the valves and pistons would come back to the positions shown in Fig. 3, ready to start again on a similar cycle.

The very large high-pressure clearance, comprising not only the port volume and the ordinary clearance between the piston and the end of the cylinder, but also the volume around the neck of the valve, which space is always in connection with

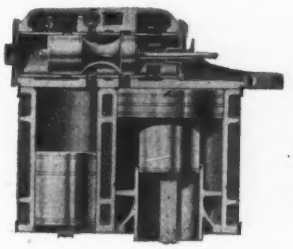


Fig. 8.

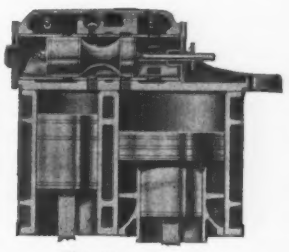


Fig. 9.

the high-pressure cylinder, appears to be opposed to all ideas of economical design, but as this clearance is never in communication with the exhaust, it is claimed that there are no free expansion losses.

The by-pass valve, which as previously stated is for clearness shown as a plain stop cock, is merely a convenience for starting. If the engine is standing with its high-pressure piston at the top of its stroke, it can be started without opening the by-pass. If, however, the low-pressure piston should be at the top of its stroke as in Fig. 9, then the valve is in such position as to close the port which admits live steam, and consequently starting in this position would be impossible. On opening the by-pass as in Fig. 9, live steam is admitted to the space around the valve, and as the valve is moving toward the right and uncovering the port to the low-pressure cylinder, as soon as the crank is a little past the centre, steam of the same pressure will be acting against both pistons. Owing to the greater area of the low-pressure piston it will descend, forcing the high-pressure piston upward. On completing half the revolution, the valve will have cut off communication between the low-pressure cylinder and the space around the neck of the valve as shown in Fig. 8, leaving the pressure on the high-pressure piston only, which will consequently descend and complete the revolution. This is the only office of the by-pass valve, and it should be closed as soon as the engine

is fairly under way, and before the throttle valve is fully opened.

Grate Surface.

EDITOR THE PRACTICAL ENGINEER:

Kindly let me know how much grate surface is required by a boiler, say of 100 horse power?

Baltimore, Md. C. J.

The square feet of grate surface required per horse power can be computed from the formula

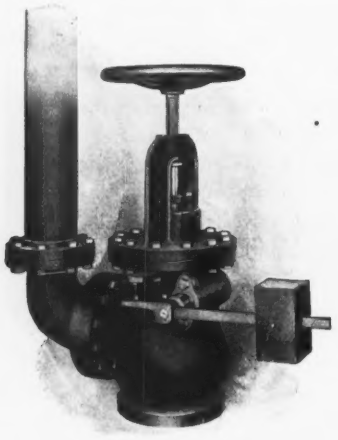
$$\frac{E \times C}{34.5}$$

in which E is the rate of evaporation and C is the rate of combustion. The product of E times C in the formula gives the weight of steam evaporated per square foot of grate per hour and by dividing 34.5 by this quantity it will give the square feet of grate required per horse power. The rate of combustion is rarely less than 15 pounds of coal per square foot of grate and the average rate of evaporation is about 9 pounds of water per pound of coal, so that $34.5 \div (9 \times 15) = .26$ square feet per horse power, so that the above boiler should have $.26 \times 100$ or 26 square feet of grate surface.—[Ed.]

The Lagonda Automatic Boiler Cut-off Valve.

The tendency of modern engineering has been in the direction of the perfection of safety devices, so that in case an accident happens, there will be some automatic device on hand ready to prevent the destruction or loss of life which the accident otherwise would cause. In the case of a power plant, there is the likelihood of the steam header bursting or of a tube giving way, in which cases unless the steam is immediately shut off, dire results might happen.

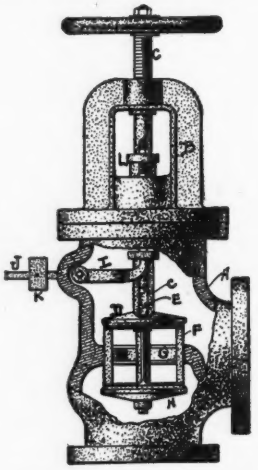
The Lagonda Automatic Stop Valve represents one of these



The Lagonda Automatic Boiler Cut-Off Valve.

safety devices which acts so that in case the steam header breaks, it shuts off all the boilers, or if a tube fails, it shuts off that boiler from the steam header and localizes the trouble. It works instantly either way and depends directly for its action upon the flow of steam through the valve.

The cross section of the valve is shown in the accompanying illustration. A is the main body of valve; B the yoke; C the main stem; D the upper valve with sleeve E, in which small end of stem C works loosely; F is the spider between valves D and H, which fits the bore in the seat and guides the valves to their seats; G is the double valve seat, seating D on the top and H on the bottom; I is the forked lever, which rocks freely up and down and holds the valves in their normal working position; J is a forged lever which carries weight K and works on same stem as lever I, balancing weights D, F and H; L is the brass stuffing-box gland.



Sectional View of Lagonda Automatic Boiler Cut-Off Valve.

When in its normal position, the upper valve rests upon its seat and prevents the steam from entering the boiler as, for instance, when the boiler is shut down. When steam is raised, it remains closed until the boiler pressure slightly exceeds the pressure in the main; then the valve lifts and steam flows from the boiler into the main. The valve is very nearly balanced by the weight and a slight flow of steam raises it to the mid-position, as shown on sectional cut. At that point the weight strikes a rest and the valve remains in the mid-position permanently, while steam is being drawn from the boiler, except in the case when a break should occur beyond the valve, when the excessive rush of steam will carry the lower valve up against the seat, shutting off the boiler. Should anything happen within the boiler, the reverse flow of steam would cause the upper valve to drop upon its seat and shut off the main.

The rate of flow at which the boiler would be shut off is determined by the weight of the valve and the distance between the two valve faces. This is adjusted to correspond to the greatest overload at which it is desired to operate the boiler, say, a little over twice the normal rated capacity or when the water begins to rise in the gauge glass.

One of the earliest valves of this design was placed in the boiler house of a smelter at the Anaconda Mines, Anaconda, Mont., in 1904, and since then, it is said, that while the boiler has been frequently shut down for repairs and cleaning, it has never been necessary to touch the valve. The fireman simply stops firing and the valve cuts the boiler out. After cleaning, the boiler is fired up again and when steam pressure becomes the same as the pressure in the main, the boiler cuts in again.

A large number of tests have been made to see how it would

act in cases of accident. Valves opening into the atmosphere were placed above and below the automatic valve and when these were opened both slowly and rapidly, the automatic valve is said to have operated perfectly.

These valves are manufactured by the Lagonda Manufacturing Co., of Springfield, Ohio, where other information can be obtained.

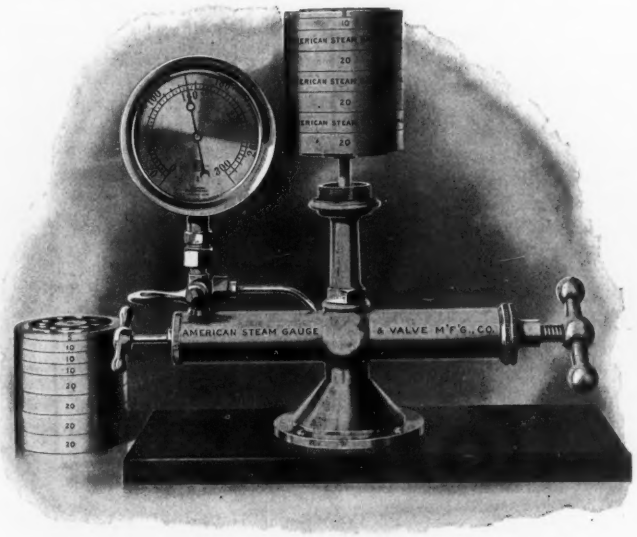
The American Dead Weight Gauge Tester.

It is one of the most usual occurrences, when looking over a battery of boilers, to find the steam gauges varying as much as five or ten pounds. This is very misleading and since a gauge is put on a boiler to indicate what pressure there is within it, effort should be made from time to time to find out if the gauge is reading correctly.

One of the simplest and most accurate instruments for testing the accuracy of a gauge is shown in the accompanying illustration and is the result of years of experiments which the American Steam Gauge and Valve Mfg. Co. has made along this line.

Referring to the line cut, the gauge tester consists of a main pump cylinder B, connected directly with cylinder G and piston F of known area, operated by weights conforming to the area of the piston. Cylinder C has a screw plunger for raising or lowering piston F under weight. Auxiliary oil chamber A has a plunger for filling the connection to gauge and main pump cylinder through three-way cock D. The oil is contained within the pump at all times, eliminating the necessity of pouring it in and out before and after testing.

When in use, chambers A, B and C are filled with a light mineral oil, chamber A being filled through cock D and chambers B and C being filled through cylinder G. The gauge to be tested is connected to suitable connections at the top of cock

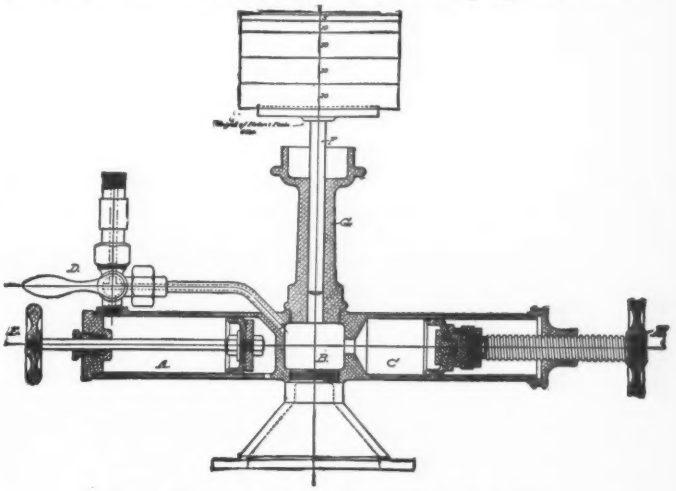


The American Dead Weight Gauge Tester.

D. Place the handle of cock D down, pull out handle E until the gauge shows pressure and the tube is filled. Then turn D to the position shown in cut, which then connects the gauge to be tested with the chamber B.

In testing, the plate on piston F should be kept about 2 inches above cylinder G, which can be regulated by screwing handwheel H. Weights, giving known pressures, are then placed on piston F and the corresponding readings of the gauge can be taken and the gauge adjusted to read correctly.

When the test is completed, the handle D should again be turned down so that the oil is drawn from the gauge tube back



Sectional View of American Gauge Tester showing Construction and Operation.

into chamber A. The oil is thus contained within the pump at all times, eliminating the necessity of pouring it in and out before and after testing.

It is said that while these gauge testers have only been on the market for eight or ten weeks, they are already used by the Government and a number have been introduced into stationary plants. For illustrated circular, address American Steam Gauge and Valve Mfg. Co., 208 Camden St., Boston, Mass.

The Lunkenheimer Premier Gas Engine Lubricator.

A new form of gas or gasoline engine oil cup, known as the Lunkenheimer Premier Lubricator, which is especially designed to give positive and proper lubrication to the engine cylinder, is shown in Fig. 1. The cup is made entirely of

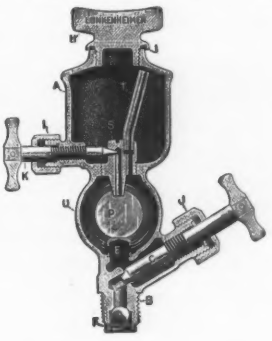


Fig. 1.

bronze composition, which is finished throughout, and is so constructed that there is no liability of its shaking to pieces, owing to the jarring of the engine.

The cup is filled at the top through a large hole, which permits the use of a can having a large spout. A tight joint between the filling plug H and top of the cup is insured by the use of a lead washer I, which conforms to any irregularity

which might exist between these bearing surfaces. It is said that this gasket will last indefinitely but should it wear, it can easily be renewed. To permit of refilling the cup when the engine is running, the valve C has been provided.

The regulation of the feed is accomplished by means of the valve K. This valve is provided with a fine needle point and as the thread on the stem has a very fine pitch, a close regulation can be obtained. The stuffing-box L serves the purpose of preventing the leakage around the valve stem K, and at the same time enough pressure can be brought to bear on the stem so that the unseating of the valve can be prevented. The object of the tube T, within the cup A, is to equalize the pressure on the oil, which permits the oil to drop by gravity through the sight-feed and thence to the cylinder.

To provide against the back pressure (which will more or less escape past the pistons) interfering with the proper formation of the drops in the sight-feed, and causing oil to spatter around the glass, the shank B, shown in detail Fig. 2, is fitted with a large ball check valve D. It has been found, however, that where the back pressure is unusually great, as in engines with worn piston rings, the ball check does not entirely remedy this trouble. To meet this condition, a baffling cap E has been provided just above the valve C. The gases escaping past the ball check D are muffled and diffused by means of cap E, and hence the drops form freely and steadily and the sight glasses never fill up.

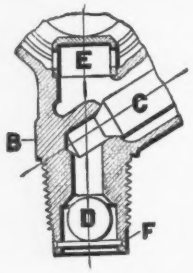


Fig. 2.

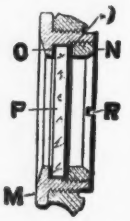


Fig. 3.

The construction of the sight-feed is shown in detail, Fig. 3. This consists of the holder M, retaining the ring N, two rubber washers OO, and the "Bull's Eye" sight-feed glass P. The glass is made very strong so that it will not break except from external causes, in which case the glass can be replaced by removing holder M, then the retaining ring N, by placing a nail in one of the slots R and giving it a slight tap with the hammer. The new glass can then be inserted and tightened.

The Premier lubricator is manufactured by The Lunkenheimer Company, of Cincinnati, Ohio, who will be pleased to give any further information about it.

Book Reviews.

Hendricks' Commercial Register of the United States for Buyers and Sellers. 15th Annual Edition. Size, 7 x 10. 1,275 pages, 350,000 names and addresses, 15,000 business classifications. Published by S. E. Hendricks Co., 76 Elm St., New York City. Price, $10.00.

Each year that the Hendricks' Commercial Register is published, it shows vast improvement in the classification of business names and addresses and a greater number of names under each classification than the year before, and this year shows a greater improvement than ever before.

The book is devoted especially to the interests of the mechanical, engineering, architectural, contracting, electrical, railroad, iron, steel, mining, mill, quarrying, exporting, and kindred industries and is one of the best books of its kind published. It should be very valuable to the buyer and seller, as there is not a manufacturer or dealer in everything employed in the manufacture of material, machinery and apparatus used in the allied industries, from the raw material to the manufactured article and from the producer to the consumer, whose name does not appear in the proper classified list.

It is also valuable as a buyers' reference, for the architect, engineer, contractor, manufacturer, jobber, retailer, machine shop, foundry, mill, factory, mine and plantation.

Book Reviews.

Water Softening and Treatment, by William H. Booth. Size 5½ x 8½. 300 pages, 92 illustrations and 41 tables. Published by D. Van Nostrand Co., New York City. Price, $2.50.

Since all natural waters contain some impurity and since these impurities are more or less deposited on the heating surface of a boiler to form scale, it is a question of prime importance to understand the process of formation and the methods of prevention so that a better efficiency of the boiler heating surface can be obtained.

This book has been written for the purpose of explaining these things. It is written in a clear manner without the use of complex chemical formula which are so very confusing to the average person.

The first portion of the book takes up the treatment of water by softening, oil separation and filtration. Under this heading the kinds of impurities water contains, the effect of various reagents, oil and heat on the water; apparatus in commercial use to prevent the formation of scale, the use of boiler compounds, oil separation and mechanical boiler cleaners are taken up in succession.

The second portion of the book is devoted to air pumps, condensers and circulating pumps. Various types of auxiliary apparatus are described in detail in this portion as well as some general pointers about the use and design of the different types. The third portion of the book takes up the question of feed water heating, economizers and the practical application of stage heating. Cooling towers are then described, together with the calculation of the amount of air required for cooling, after which feed pumps and injectors are discussed.

The title of the book does not indicate completely what its contents are, but it should prove valuable to anyone interested in the subject of scale formation and auxiliary apparatus around a power plant.

To determine the refrigerating effect produced by the evaporation of one pound of liquid ammonia at a given back pressure, a deduction must be made, from the latent heat of evaporation at that pressure, for the work required to cool the ammonia itself from the temperature at which it enters the evaporating coils to the temperature at which evaporation takes place. The temperature at which the ammonia enters the evaporating coils should be approximately that of the water used for condensing purposes.

TRADE NOTES

EDITED BY THE ADVERTISING MANAGER

Have you ordered an "eracto" Packing Gauge and Cutter? If not, you don't know what you are missing for it's about the best tool that has recently been invented for the engine room. It does away with measuring entirely. All you have to know is the diameter of the rod and the size of the packing to be used and you can cut an exact fit in two seconds, but that's only the beginning of the story. It's continued in a little booklet that tells all about the device. If you have not received one of these booklets, write for a copy to Green, Tweed & Co., 109 Duane St., New York.

H. B. Underwood & Co., 1025 Hamilton St., Philadelphia, will occupy four pages in the September issue of THE PRACTICAL ENGINEER with an elaborate description of their works, including half-tone illustrations of both interior and exterior views, and some of their many special portable tools and methods for repairing engines in position and without removal to their shops. This description will appear in the advertising section of the paper but it will be highly interesting to the many engineer friends of this old and well-known concern, and in fact it should interest every engineer who has ever had an engine accident or found it necessary to have his engine overhauled at short notice, for the reputation of Underwood & Co. has been made on their ability to handle any kind of engine repair job and to do it quickly and well.

The Richards' Corliss Engine, shown on the front cover of this issue, is well-known and exceedingly popular in Philadelphia and vicinity where hundreds of them are in service in textile mills and other manufacturing establishments. We know of no engine that has given better satisfaction or produced more economical results. The builders have published an attractive catalogue of which they will mail a copy to any one writing them or furnish any further specific information desired. Address Corliss Engine Works, 4041 N. Fifth St., Philadelphia.

The Improved type of Tripp Metallic Packing is shown in a new illustrated circular just issued by the manufacturers, Wm. B. Merrill & Co., 74 India St., Boston, Mass.

The Power and Mining Machinery Company, Milwaukee, Wis., now have on the press their catalogue No. 6 descriptive of their machinery for the Roasting, Smelting and Refining of Copper and Silver-lead Ores.

This catalogue will contain about 176 pages, size, 6 x 9 inches, amply illustrated, and will contain information of interest to the practical mining and smelting man. It will be ready for distribution about July 15th, and will be sent upon request to those interested.

One of the best opportunities that is now open to engineers and owners of small steam plants, is to start slowly, in a small way and to gradually develop a central station heating plant. There are thousands of small and medium sized boiler plants where the capacity greatly exceeds the demands upon it. How such plants can be converted into profit earners is told in a little book published by American District Steam Co., Lockport, N. Y. Write for a copy. It's worth studying.

The man who knows his business is generally a winner, but he who knows his business and also knows how to tell others about it in a manner that entertains while it instructs, and convinces all the while, will be doubly successful. The latter qualities are strongly embodied in a little booklet entitled, "Whirled to the Top," just issued by the Ohio Blower Co., Cleveland, Ohio. It tells about the Swartwout Cast-Iron Exhaust Head and gives reasons for ing, especially if you are contemplating the purchase of exhaust heads, and a copy will be the making of such a "head." It's worth readsent free to any one who cuts out the coupon on page 63.

The Ohio Blower Co., 43-47 Michigan St., Cleveland, Ohio, manufacture Dust Collectors, Furnace Feeders, Blow Piping, Exhaust Heads, Steam Separators, Blowers, Heating and Ventilating Systems, Dry Kilns and Engines. Estimates or special information will be furnished upon request.

The Brunswick Refrigerating Machine Co. have purchased the plant of the National Water-Tube Boiler Co., of New Brunswick, N. J., and will push the manufacture and sale of these boilers vigorously. Last January, when the Brunswick Refrigerating Company was reorganized, such well known men as W. Campbell Clark, who is at the head of the spool cotton trust; Theodore Frelinghuysen, who is the treasurer and the head of the selling department of the spool cotton trust; A. M. Coates and J. Henry Smith, of the Coates Thread Company; F. A. Sales, all millionaires many times over, became interested with the Messrs. Johnson in the Brunswick Refrigerating Company and the capital stock was increased to $2,000,000.

It is this Company, with this backing, which now proposes, in connection with the manufacture of refrigerating and ice-making machines, to take up the manufacture and sale of Water Tube boilers under the patents which it has bought from the National Water Tube Boiler Company.

The inventor of Sweets Separator has been manufacturing steam engines for about fifteen years, during that time his attention had been called to hundreds of cases where engines of all makes had been broken from water in the steam, cylinder head had been shoved off, pistons smashed, piston rods bent, crossheads and connecting rods either broken or rendered sadly in need of repairs, valves torn apart and valve rods made useless. In addition to this the cutting of valves, valve seats and cylinders could in many cases be traced to the same cause. This could not continue and a remedy was sought and found. The remainder of this interesting story is told in a little booklet issued by the Direct Separator Co., 220 Marcellus St., Syracuse, N. Y. It tells of Sweets Separators, their construction, operation and of the benefit they are to their users.

A catalogue describing Holmes Metallic Packing and showing several half-tone illustrations of large engines and pumps upon which the packing is in service, is issued by the Holmes Metallic Packing Co., Wilkes-Barre, Pa.

In order to handle the increased volume of business since placing on the market the C. H. Wheeler Improved Surface Condensers and the Mullan Suction Valveless Air Pump, the C. H. Wheeler Manufacturing Co., of Philadelphia, have found it necessary to make a large addition to their shops; they have also installed a quantity of new tools, many of which were built especially for their work. Feeling further expansion necessary, they have at present plans under consideration, which when completed, will double their present capacity. They also report an unusual demand for their boiler feed and underwriter fire pumps.

Wanted Salesmen traveling among engineers to sell the France Metallic and Fibrous Packings. Good inducements on unoccupied territory, Address
FRANCE PACKING Co., Tacony, Phila., Pa.

PATENTS Watson E. Coleman, Patent Attorney, Washington, D. C. Advice free. Terms low. Highest ref.

PATENTS Procured ISEDORE S. PRENNER, E.E. Attorney-at-Law, Solicitor of Patents, Consulting Engineer, Law, Patent and Engineering Cases.
Room 1108 Betz Building, Philadelphia.

PATENTS PROMPTLY SECURED. Highest references from prominent manufacturers. Write for Inventors' Hand-Book, SHEPHERD & PARKER, 186 Deitz Building, Washington, D. C.

THE WATER WAY
BETWEEN
Buffalo and Detroit

The D. & B. Line Steamers leave Buffalo daily at 5:30 p.m. (eastern time) and Detroit week days at 5:00 p.m., Sundays at 4:00 p.m. (central time) reaching their destination the next morning. Direct connections with early morning trains. Lowest rates and superior service to all points west.

Rail Tickets Available on Steamers

All classes of tickets sold reading via Michigan Central, Wabash and Grand Trunk Railways between Buffalo and Detroit, in either direction, will be accepted for transportation on D. & B. Line Steamers. Send 2 cent stamp for illustrated pamphlet. Address
A. A. SCHANTZ, G.S. & P.T.M., Detroit, Mich.
Detroit & Buffalo Steamboat Co.

The Quaker City Rubber Company, Philadelphia, has just issued a new catalogue devoted exclusively to the packings they manufacture.

It has twenty-four pages bound in an attractive cover and contains over thirty fine half-tones of packings.

Special care is shown in illustrating their famous P. P. P. Rod Packing, in ring, coil and spiral form.

Their Ebonite Sheet Packing—which they claim to be without an equal—is handsomely illustrated in two colors.

As the Quaker City Rubber Company manufacture packings for all purposes, the booklet will serve as a handy guide for the engineer in search of the right packings.

We predict this booklet will be most popular among the engineers and would suggest that you write for a copy.

Mr. Thos. G. Keogh has opened an office at 434 Park Row Building, New York. Mr. Keogh informs us that he is prepared to take up and push the sale of steam specialties of merit and will be pleased to correspond with manufacturers who desire efficient representation in the New York market. Mr. Keogh is well known in the steam field as a high-grade and thoroughly reliable salesman.

The Oswego Boiler and Engine Co., Oswego, N. Y., make a specialty of manufacturing circular steel tanks for gas, gasoline, air and water for use as blow-off, receiving, drip, pressure or hot water tanks. They have just issued a new tank catalogue giving sizes, capacities, prices, etc., which should prove interesting to engineers. A copy will be mailed by them to any one interested.

The United States Treasury Department has awarded the annual contract for boiler compound to the Geo. W. Lord Company, of Philadelphia.

An analysis of feed water for each of the many government buildings is made several times per year by Lord's laboratory and special chemicals for each case supplied by them.

The Geo. W. Lord Company claim to be the originators of manufacturing boiler compounds in this scientific manner and it is not surprising that the United States, as well as several other Governments, have adopted their products as standard.

Frederick H. Mason, Detroit, Mich., has become the representative for the Alphons Custodis Chimney Construction Co., for the State of Michigan. He still continues as sales agent in that territory for the well-known Cochrane Feed Water Heaters, Sorge Cochrane Purifying System and Cochrane Separators.

Thos. C. Warley & Co., 221 S. Front Street, Philadelphia, Pa., manufacturers of the well-known Warley's Boiler Cleansing Compounds, whose advertisement appears on another page of this paper, inform us that there is a large and increasing demand for their products, which they attribute to the high quality and efficiency of their goods, and the absolute guarantee given with each package that it will do the work for which it is intended. They have just completed a large order for San Francisco, which was ordered shipped all rail to avoid delay. They are also exporting large quantities of compound, having agencies in many of the principal cities of the world. This firm has been in business for a great many years, and is now fully prepared to handle the most difficult cases of scaled boilers and give satisfactory results. Engineers and steam users who have experimented with other compounds without satisfactory results will do well to communicate with this firm, and their inquiries will receive careful and prompt attention.

The American Dead Weight Tester is a new improved device for testing steam gauges, and all other pressure gauges. It is described in a neatly printed circular just issued by American Steam Gauge Co., 208 Camden St., Boston, Mass. A copy will be mailed to any one interested.

The Ruggles Perfection Flue Cleaner is inexpensive and a mighty handy thing to have about the boiler house. It is sent on 30 days' trial to responsible parties. Write for "Blue Book" to Scully Steel and Iron Co., Halstead, Fulton and Wayman Sts., Chicago.

We have not often seen a more attractive catalogue of packings than a new one just received from The Charleston Metallic Packing Co., of Charleston, S. C. In addition to describing the original Charleston Metallic Packing, it also shows a very complete line of fibrous packings for every grade of packing service, including sheet packing for various uses, pump valves and gaskets, all of which are attractively illustrated with excellent half-tone cuts. The Company want to send a copy to every engineer who writes for it.

The Williams Gauge Company have opened an office at Montreal, which will be conducted by Mr. Wm. M. Courtenay. This is the third office in the Dominion of Canada now operated by this Company, who have found it necessary to handle the business which has been coming to them from that country.

An attractive booklet published by the New England Roller Grate Co., Whitney Building, Springfield, Mass., describes the construction and operation of their grates. These grates have made some remarkable records during the past five or six years and have become highly popular with all who have used them.

GRAPHO

SOMETHING NEW

A new preparation for enriching oils.
Will suspend in oil.
No more Hot Journals.
Engineers who have tried same claim it to be the best yet.

SEND FOR SAMPLE

A trial will convince you

AGENTS WANTED

GRAPHO MFG. CO.

Cor. Frank and Commercial Sts.
ROCHESTER, N. Y.

F. A. Genth, Jr.

Analytical and Consulting Chemist

222 WALNUT STREET

Telephone **Philadelphia**

NEW EDITION

Care and Management of

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A practical book for the practical man, containing a fund of valuable information for those who have to do with Electric plants.

Among others there are chapters on

Storage Batteries
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294 Pages **203 Illustrations**

Handsome Full Limp Leather, - $2.50
Cloth, - - - - - - $1.50

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The Smith Pipe Clamp

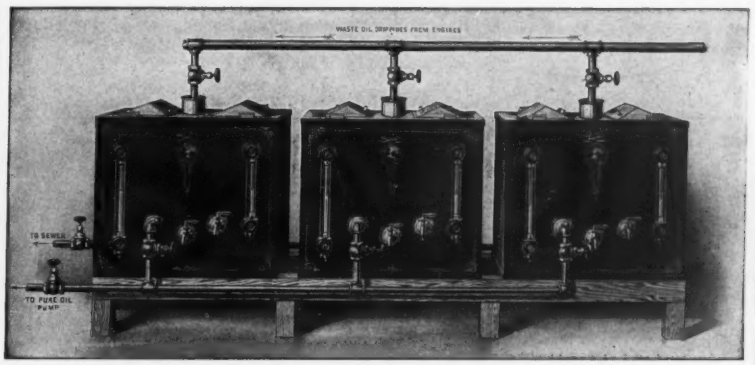
Stops The Leak Every Time

A complete set for every size of pipe in your plant will save many a dollar. Quickly applied while pressure is on the pipe WE GUARANTEE TO STOP THE LEAK. Steel or brass, all sizes, ¼-inch to 20-inch. No trouble to send further information.

W. CLIFFORD SMITH

138 N. SIXTH STREET
PHILA., PA., U. S. A.

"Unit" Oil Filters



Three "Units" Connected and Operated as One Filter.

"Unit" Oil Filters

Reduce Lubricating Oil Bills 50 per cent.

It will successfully handle heavy and light grade oil. We guarantee this.

Each "Unit" is 42 inches long, 3 feet high and 28 inches wide and has a filtering capacity of from 175 to 225 gallons per day.

Each "Unit" is so constructed that it can be used with or without an oiling system and as the power increases additional "Units" can be installed and connected with present filters.

The Philadelphia Rapid Transit Company have 10; United States Steel Corporation 4; Baldwin Locomotive Works are using 1; the Calumet and Hecla Mining Company 7, and John D. Rockefeller has purchased 2 for the new office building recently erected in Cleveland, Ohio.

This shows you where but 24 of over the 20,000 Oil Filters which we have made in our 14 years' experience are. We send them on 30 days' trial.

The Burt Exhaust Head

is cheaper than a new roof.

It prevents drenching and rotting of the roof.
It prevents icy sidewalks and damage suits resulting from them.
It positively removes water and oil from exhaust steam lines.
The Toledo Heating & Lighting Company says:

Toledo, O., October 20, 1893

The Burt Mfg. Co.,
Akron, Ohio.

Gentlemen: We are in receipt of your favor of the 19th inst., and in reply would say that the three Burt Exhaust Heads are giving us entire satisfaction. In fact, they are the best thing in that line that we know of. Even though at times they are worked above their capacity, we have failed to see any water get past them, and when they are worked at their capacity, we find them practically noiseless and a great aid in muffling the exhaust.

Yours truly,
The Toledo Heating & Lighting Co.,
Per Ed. Befaryan, Supt.

This letter is characteristic of how all customers feel.
You will too when you get one.
Our 48-page catalog describes our full line of Oil Filters, also The Burt and Standard Exhaust Heads. Copy sent on request.

The Burt Mfg. Co. Largest Manufacturers of Oil Filters in the World. 204 Main Street, AKRON, OHIO, U. S. A.

Carried in stock by Shelby & Co., 66 Leonard Street, London, E. C., England, Sole Agents for Great Britian.

NO man may call himself a successful business man until he has mastered the science of advertising his product successfully. Every cent's worth of business that you do, results from advertising in some form!

Many a good man has remained on the lower rungs of the ladder because he failed to recognize the meaning of that statement.

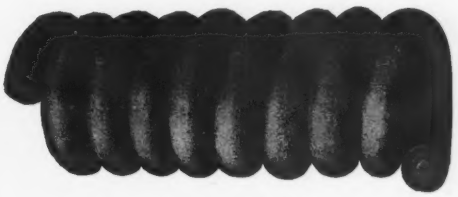
Not all things can be advertised successfully in the same way, but all things of merit can be advertised successfully in some way, and the men who make a study of advertising in its various forms all agree that the engineering papers offer the most direct and economical route to the consumer of power plant equipment and supplies.

The Practical Engineer is read in Seventeen Thousand engine rooms by engineers who buy it and pay for it, because they want it. They are our friends, it is their confidence in the paper that has made it.

During the past month we have received six letters from six of the largest advertisers in the steam field each saying that the returns from The Practical Engineer are greater than from any other paper. Two of these letters from two of the very largest advertisers say that the returns from The Practical Engineer exceed the returns from practically the same copy in all other engineering papers combined. These letters form a mighty convincing bunch of evidence, you can see that if you are interested.

Any advertiser is invited to examine our paid subscription list and Post Office mailing receipts at any time.

PEERLESS PISTON and VALVE ROD PACKING



Made with Round Core of the celebrated Rainbow Packing Compound, surrounded by layers of soft, loosely woven duck, thoroughly impregnated with finest grade of plumbago lubricating material.

WILL HOLD 400 LBS. OF STEAM.

WE MAKE THE PEERLESS PISTON AND VALVE ROD PACKING ROUND, SQUARE, SPIRAL AND IN RINGS.

WE CONFIDENTLY BELIEVE THIS PACKING TO BE FAR SUPERIOR TO ANY PISTON AND VALVE ROD PACKING ON THE MARKET.

DON'T WAIT! *ORDER A BOX TO-DAY!*

SUCCESS SEMI-METALLIC DIAGONAL EXPANSION SPIRAL PACKING RAINBOW CORE

Patented Oct. 31, 1899.

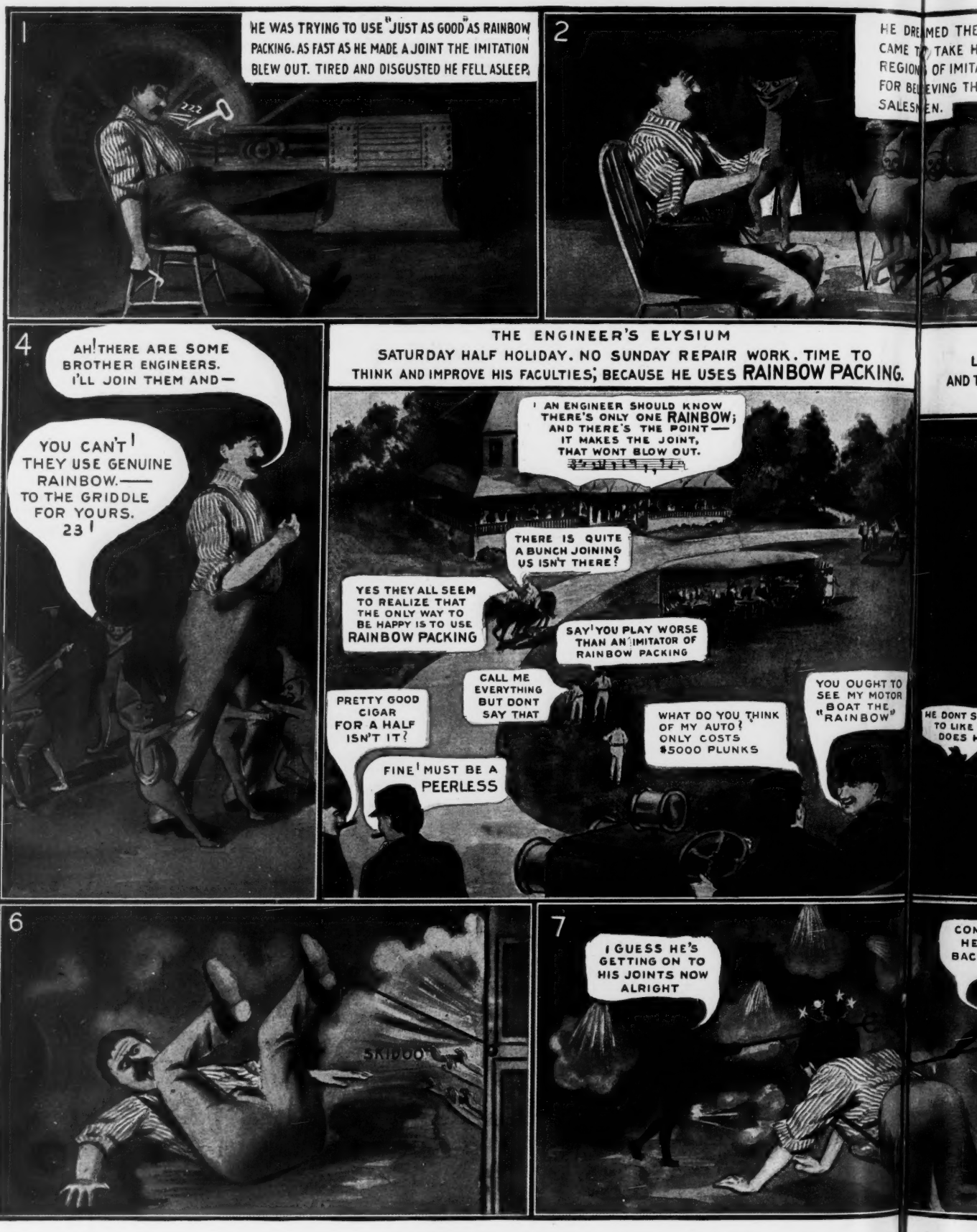
The "Success" is the "Best" Combination Packing yet devised, both as regards principle of Construction and Material used, for Steam, (low or high pressure), for Water (hot or cold), and for Ammonia Machines.

The Spiral form is the correct shape of all Modern Constructed Packing, and readily and quickly conforms to the ring shape so greatly desired. The Soft Metal used is a Wear Resister; it is an Automatic Expander under heat conditions; it will not scratch or cut the rod under any conditions.

Manufactured, Patented and Copyrighted Exclusively by

Peerless Rubber Manufacturing Co.

16 Warren Street, New York


1
HE WAS TRYING TO USE "JUST AS GOOD" AS RAINBOW PACKING. AS FAST AS HE MADE A JOINT THE IMITATION BLEW OUT. TIRED AND DISGUSTED HE FELL ASLEEP.
2
4
AH! THERE ARE SOME BROTHER ENGINEERS. I'LL JOIN THEM AND—
YOU CAN'T! THEY USE GENUINE RAINBOW.— TO THE GRIDDLE FOR YOURS. 23!
THE ENGINEER'S ELYSIUM
SATURDAY HALF HOLIDAY. NO SUNDAY REPAIR WORK. TIME TO THINK AND IMPROVE HIS FACULTIES; BECAUSE HE USES RAINBOW PACKING.
I AN ENGINEER SHOULD KNOW THERE'S ONLY ONE RAINBOW; AND THERE'S THE POINT— IT MAKES THE JOINT, THAT WONT BLOW OUT.
THERE IS QUITE A BUNCH JOINING US ISN'T THERE?
YES THEY ALL SEEM TO REALIZE THAT THE ONLY WAY TO BE HAPPY IS TO USE RAINBOW PACKING
SAY! YOU PLAY WORSE THAN AN IMITATOR OF RAINBOW PACKING
CALL ME EVERYTHING BUT DONT SAY THAT
PRETTY GOOD CIGAR FOR A HALF ISN'T IT?
FINE! MUST BE A PEERLESS
WHAT DO YOU THINK OF MY AUTO? ONLY COSTS $5000 PLUNKS
YOU OUGHT TO SEE MY MOTOR BOAT THE "RAINBOW"
6
SKIDOO
7
I GUESS HE'S GETTING ON TO HIS JOINTS NOW ALRIGHT

ENGINEERS DESIRING A COPY OF THIS PICTURE CAN OBTAIN SAME ON APPLICATION TO THE COMPANY.

PATENTEES AND SOLE MANUFACTURER

THE PEERLESS RUBBER M

16 WARREN STREET,

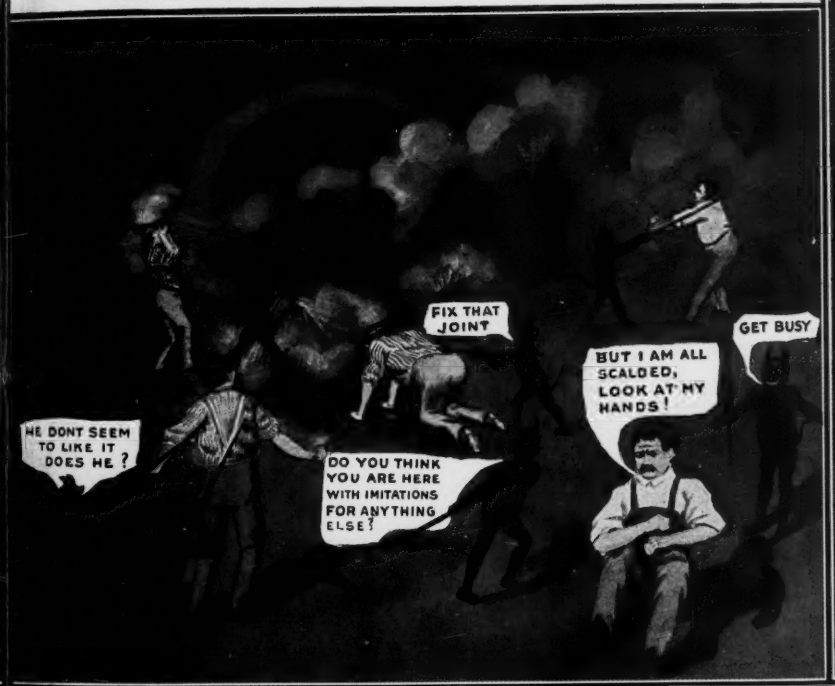
HE DREAMED THE TROUBLE MAKER CAME TO TAKE HIM TO THE HOT AIR REGIONS OF IMITATIONS AS A PUNISHMENT FOR BELIEVING THE STATEMENTS OF FAKE SALESMEN.

3

IT'S TOUGH, BOYS—STILL IT CAN'T BE WORSE FOR ME THAN WHEN I WAS USING WORTHLESS IMITATIONS OF RAINBOW. OH! OH! WHY DID I USE THAT MISERABLE STUFF.
TO THE FIRE BOX BOYS!

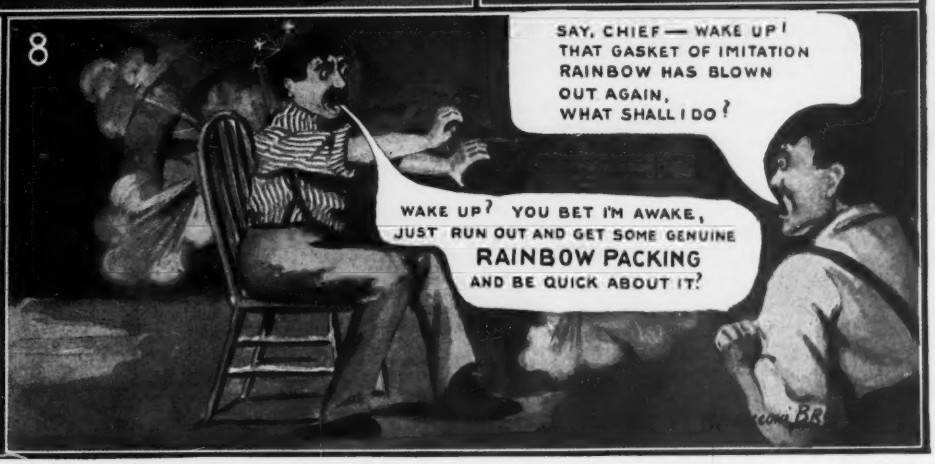
THE ENGINEER'S DELIRIUM

LEAKY JOINTS. WORK ALL SATURDAY AFTERNOON AND SUNDAY AND THREE TO FIVE NIGHTS EVERY WEEK MAKING REPAIRS. DRUDGERY. BECAUSE HE USES "JUST AS GOOD" AS RAINBOW.


FIX THAT JOINT
GET BUSY
BUT I AM ALL SCALDED, LOOK AT MY HANDS!
HE DONT SEEM TO LIKE IT DOES HE?
DO YOU THINK YOU ARE HERE WITH IMITATIONS FOR ANYTHING ELSE?

5

8


SAY, CHIEF — WAKE UP! THAT GASKET OF IMITATION RAINBOW HAS BLOWN OUT AGAIN, WHAT SHALL I DO?
WAKE UP? YOU BET I'M AWAKE, JUST RUN OUT AND GET SOME GENUINE RAINBOW PACKING AND BE QUICK ABOUT IT!

ZEESE-WILKINSON CO. N. Y.

UFACTURERS OF RAINBOW PACKING

BER MANUFACTURING CO.

TREET, NEW YORK.

THE ECLIPSE SECTIONAL RAINBOW GASKET

The original and only genuine Sectional Gasket—manufactured from the celebrated Rainbow Packing Compound. Beware of cheap tubings and worthless imitations. Be sure the name Eclipse is embedded in the gasket at intervals of six inches

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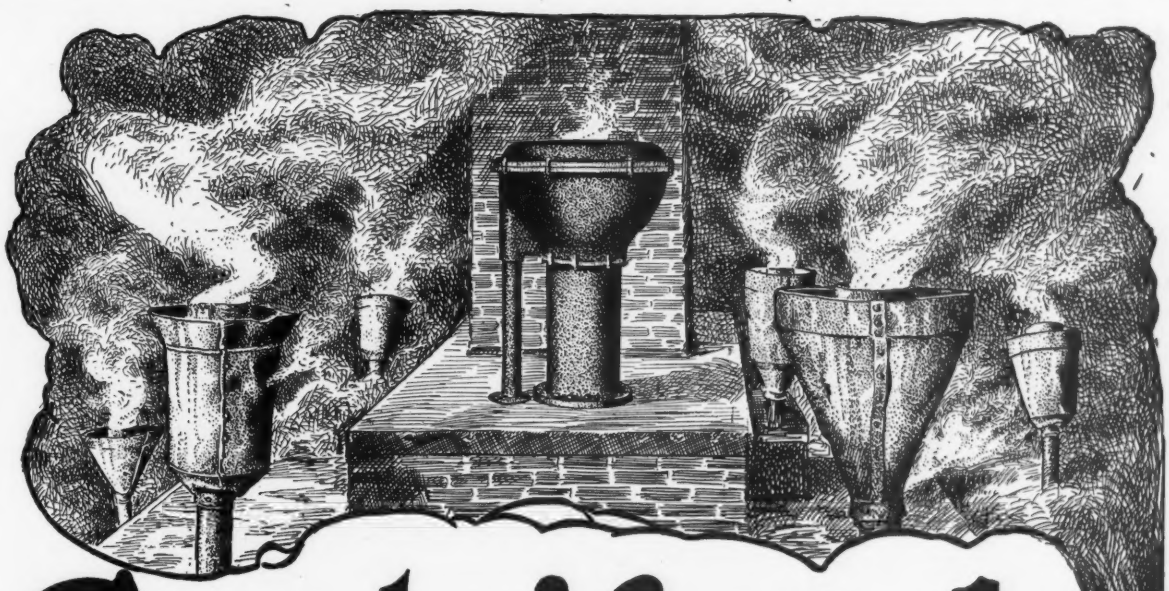

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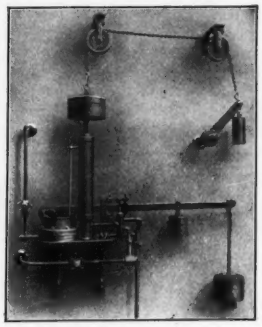

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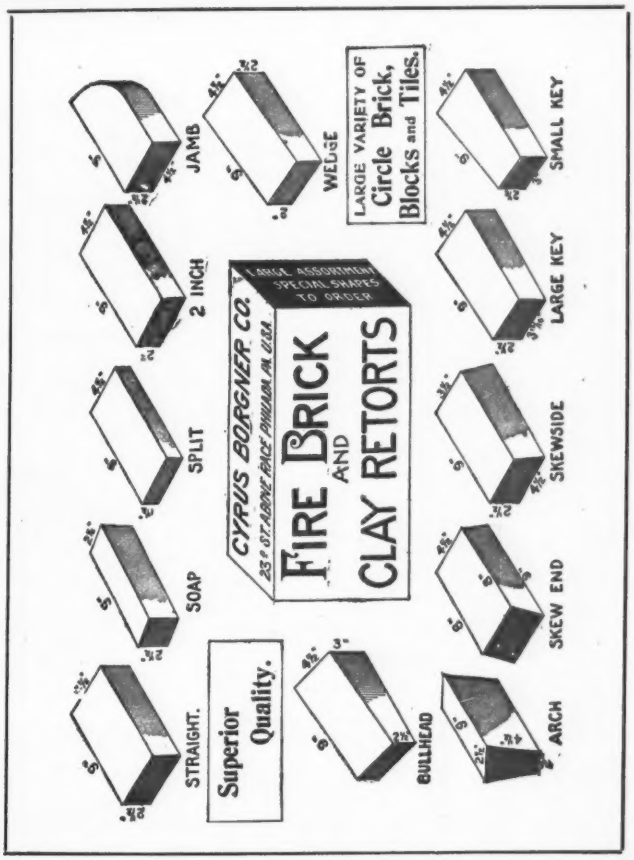

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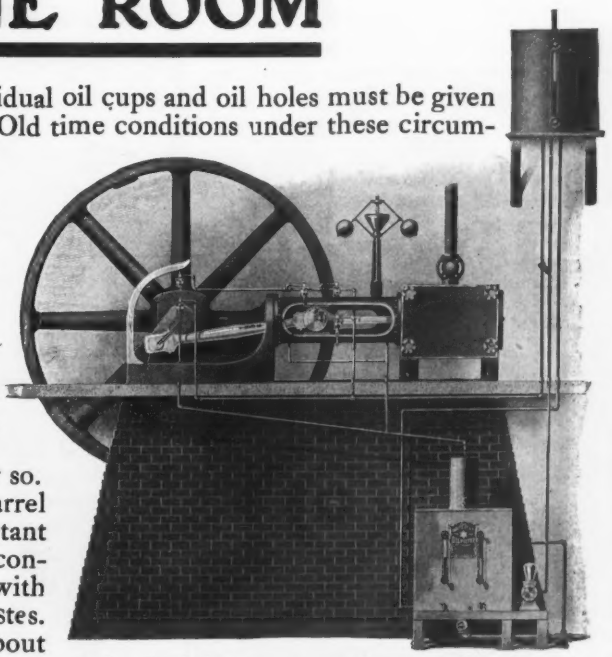

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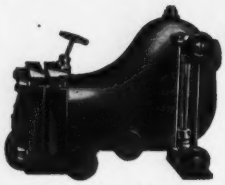

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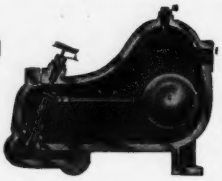

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ESTABLISHED 1878
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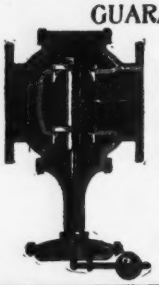
GUARANTEED TO GIVE ENTIRE SATISFACTION



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of cleaning water tube boilers. With a Demon cleaner to help you the scale nuisance is taken care of easily and quickly. After years of experience with various forms of boiler cleaning machines, we came to the conclusion that there were certain essential features a good cleaner must possess.

1st. The action of the cleaner should be rotary, not oscillating.

2d. The motor should be part of the machine and so powerful as to crush and crumble the hardest scale and not stop to grind it out.

3d. Water should be motive fluid, so that the exhaust will carry away the loosened scale.

4th. The cutter arms should be held out against the work in a positive manner—*i. e.,* no inward movement so that no scale can possibly be passed over.

5th. The outward movement of the cutters to be also limited to prevent any injury to tubes and relieve the cutters of wear.

6th. The machine should have large strong parts so as to be exceedingly durable.

7th. Its water consumption should be proportional to the work accomplished.

8th. The machine should be simple in design and operation and easily handled by a single operator.

Every one of the above requisites is found in the "Demon" cleaner. We absolutely guarantee it to remove any scale, no matter how thick or how dense. It is not a turbine in any sense. It is a piston cleaner. Its power and rapidity enable it to accomplish in minutes what other cleaners require hours to do. It polishes the tube like a gun-barrel. Send for a "Demon" on free trial. If it isn't the best machine you ever saw, don't buy it!

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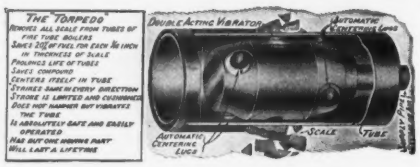
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REMOVES ALL SCALE FROM TUBES OF FIRE TUBE BOILERS
SAVES 20% OF FUEL FOR EACH 1/16 INCH IN THICKNESS OF SCALE
PROLONGS LIFE OF TUBES
SAVES COMPOUND
CENTERS ITSELF IN TUBE
STRIKES BLOWS IN EVERY DIRECTION
STROKE IS LIMITED AND CUSHIONED
DOES NOT HAMMER BUT VIBRATES THE TUBE
IS ABSOLUTELY SAFE AND EASILY OPERATED
HAS BUT ONE MOVING PART
WILL LAST A LIFETIME
DOUBLE ACTING VIBRATOR
AUTOMATIC & SELF-ADJUSTING CUTTERS
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SCALE
TUBE

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Send your address and also ask for catalog "P."

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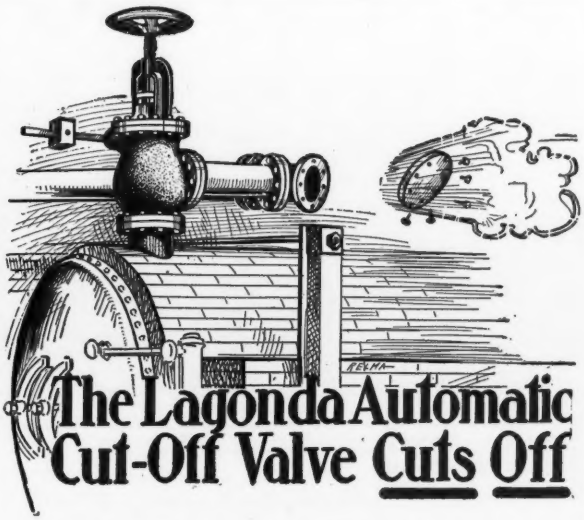

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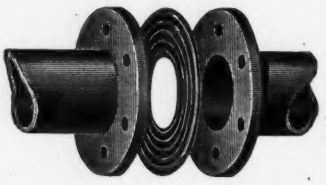

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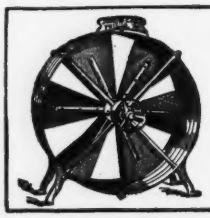

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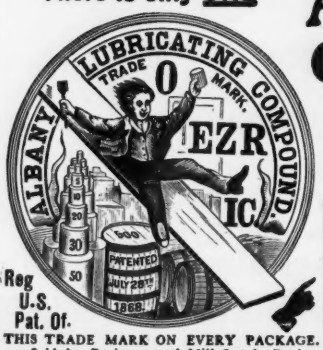

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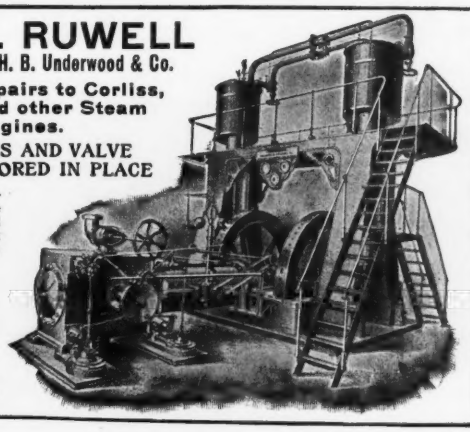

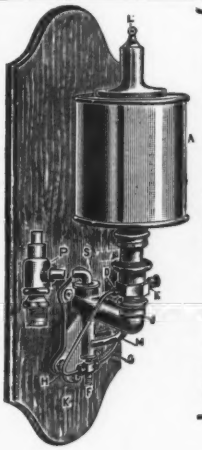

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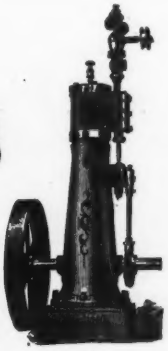

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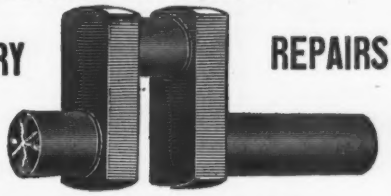

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SPECIAL REPRESENTATIVES OF INDICATOR INSTRUCTION CO.

NEWARK, N. J., July 19, 1906

The Practical Engineer,
46 North 12th St.,
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Gentlemen:-

We have your valued favor of the 17th inst., asking how we like the Practical Engineer as an advertising medium. Before answering your question we wish to express our thanks for your interest in this matter, as the publishers of some papers do not seem to care much whether their clients receive much benefit or not, as long as they continue to advertise, and as we have a two years' contract with you, we know your letter was prompted by motives of interest in our welfare, and for this reason we appreciate it fully.

As you know, the writer has advertised in the Practical Engineer almost from the start, and is therefore able to judge of its growth. We can state without any hesitation that the results from your paper are on an average equal to any we advertise in, and during some periods are much greater. For instance, in one day, the Practical Engineer inquiries equalled those from all other papers combined.

You will remember that in a recent issue we inserted a coupon to be used in purchasing our new Junior reducing wheel, the use of the coupon being limited to twenty days. Before that time had expired we had orders for more of these wheels than we cared to take, having by that time ascertained that the shop cost would be greater than the price we quoted, this being an instance where the results were too good.

The commendable feature of your paper is that it is written for engineers on topics they are interested in and we think this is largely the secret of your success. Personally, we do not see how you can publish such a paper for the money, but presume you are doing it for the same reason that we are furnishing an Indicator Instruction Course and Simplex Indicator for such a low price, the reason being that we believe a large volume of business at small profit is better in the end than high prices and limited sales. We would state in conclusion that if any prospective advertiser desires to investigate the results of our advertising in your paper, we shall be very glad to give them all the information they desire if they will call at our office.

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Yours very truly,

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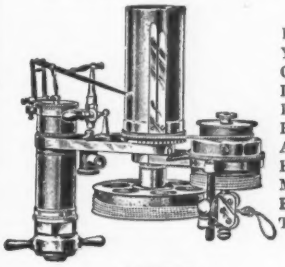

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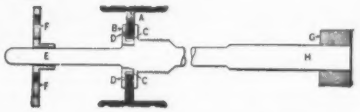

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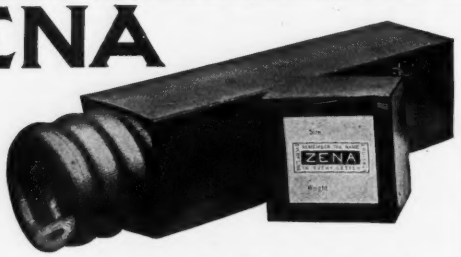

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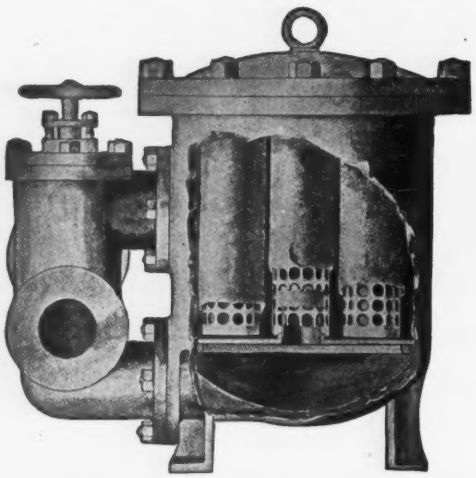
Filtered Feed Water Prevents Scale



The Blackburn Smith Patent Feed Water Filter and Grease Extractor will remove all the mud and grease from your feed water, prevent scale and save you the cost of boiler compounds and wasted fuel. Can be placed either on the suction or discharge scale of feed pump. Easy to clean. Made in all sizes. Write for Catalogue.

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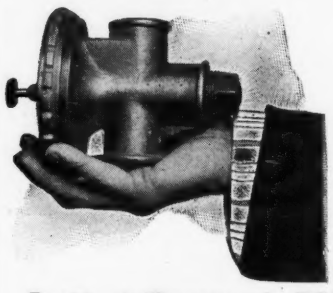

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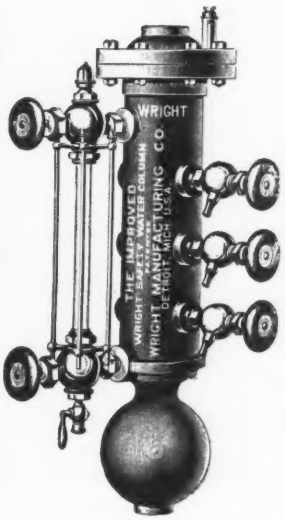

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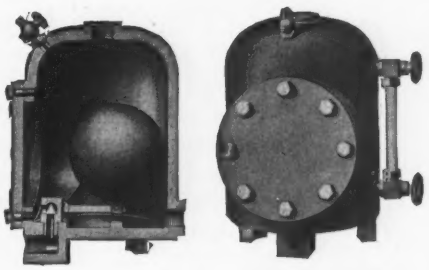

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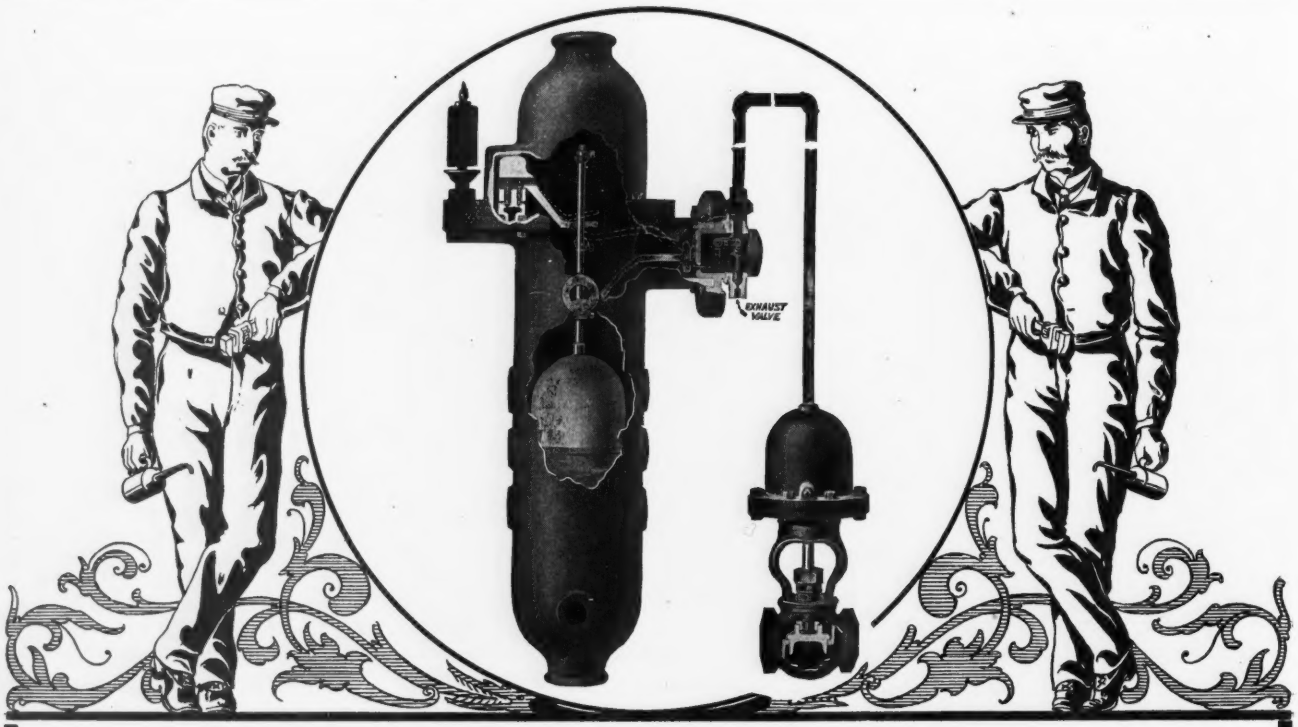

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Automatically controls the admission of feed-water to the boiler, admitting a little at a time as frequently as required, thereby permitting the maintainance of a uniform fire, which insures a constant saving in fuel and repairs. A large majority of all the repair work in a steam plant is the result of irregular admission of the feed-water and the consequent irregular firing. The Williams prevents all of this and protects you against boiler explosion or other accidents due to low or high water in the boilers.

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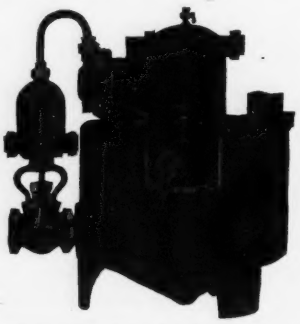
looks different from others, and so it is. It will keep your steam lines free of condensation. It has a quick acting valve operated by steam pressure. It blows the water out like a shot and closes just as quick. No wire drawing with this trap.



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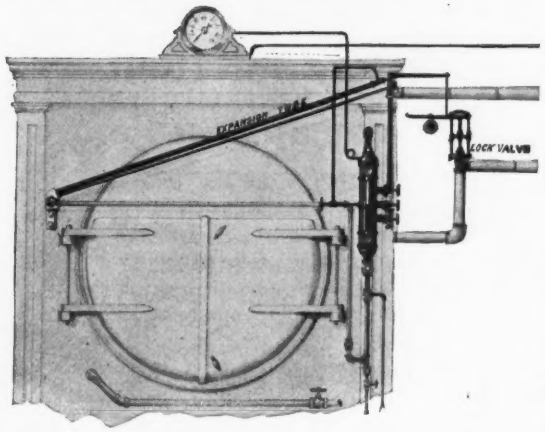
Cannot Fail.



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Scores of these regulators have been in constant use for the past ten years and are working just as accurately as the day they were first installed, without having cost one cent for repairs or maintenance. Every Engineer who has one is enthusiastic about it. It is simple and positive in operation, and will last as long as the boiler.

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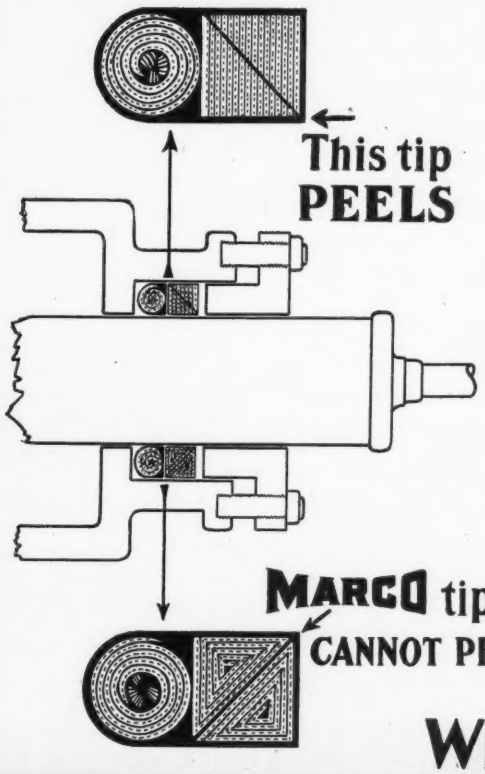

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WE want to send you a full barrel of Philadelphia Grease freight prepaid without any obligation on your part to buy it unless you want to do so.

Then we will also send you EIGHT BRASS GREASE CUPS suitable for your engines or other machinery for which we make no charge.

That's our plan—our new plan of selling Philadelphia grease.

Now, we don't say "Send us your order for a barrel and if not satisfactory we will refund your money." That is not our way. You might feel that there was some doubt about getting your money back if you wanted it, and we don't want you to feel that way.

SIMPLY DO THIS write us a letter and tell us the H. P. of your engine, the R. P. M. and state where the cups are to be placed, giving the size of the tap for each cup. The letter should be on your business stationery and signed by some one in authority.

Then we take all the risk and send you, freight prepaid, a barrel of Philadelphia Grease and eight brass cups.

You see, Philadelphia Grease is so much better than any other grease that we can afford to send it out this way feeling certain that you will want to keep it and that you will become a regular customer.

When you receive the barrel, open it up, apply the cups and use as much of the grease as you want to give it a thorough trial.

When you have tested it three weeks, if you find it the best lubricant you ever used, better than any oil at any price and far better than any other grease, keep it. But you don't need to pay for it even then for we give you six months' credit—that's our new plan.

You see Philadelphia Grease will last so much longer than oil or any other grease that it very soon saves the entire cost of the whole barrel.

We figure, that even in a very small plant it will more than save its cost in six months so that you do not have to pay us until it has had time to save its cost. In that way we make the oil man or the other grease maker buy it for you.

If the grease does not prove to be the best lubricant that you ever used and if you are not entirely satisfied with it after a three weeks' test ship it back at our expense, also the cups, and you owe us nothing for what you have used in testing it.

Did you ever hear of anything as clever as this in the grease line?

It's this way—the reason we can make this offer is because we are not in the least doubtful about our grease, we have been making it for years, and we know that it has no equal as a lubricant for engines, and machinery of all kinds.

We do not claim that PHILADELPHIA GREASE is "just as good as some other grease." We do not even claim that it is "just as good as the best." What we do claim is that it is better than any other grease ever offered to the power using public, and we are proving it every day in actual working tests under every possible condition of power plant service in hundreds of the largest power stations and industrial plants of the world.

Philadelphia Grease is a highly refined lubricant made by an improved dry heat process from a special combination of the best quality of oils. It has a fine, close, even grain and a rich natural color which distinguishes it instantly from inferior greases. It is pure enough to lubricate a watch and cheap enough to use on any kind of machinery or line shafting.

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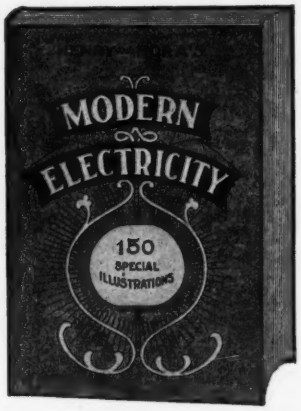

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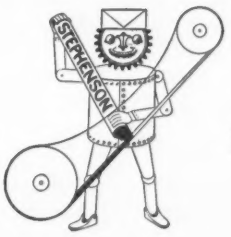

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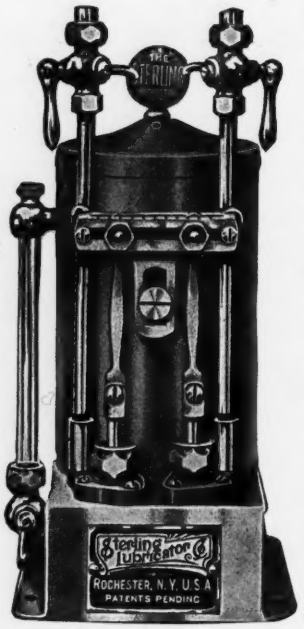

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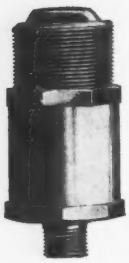

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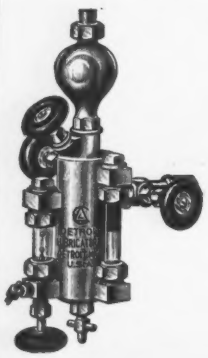

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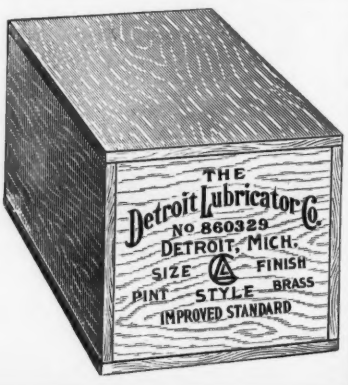

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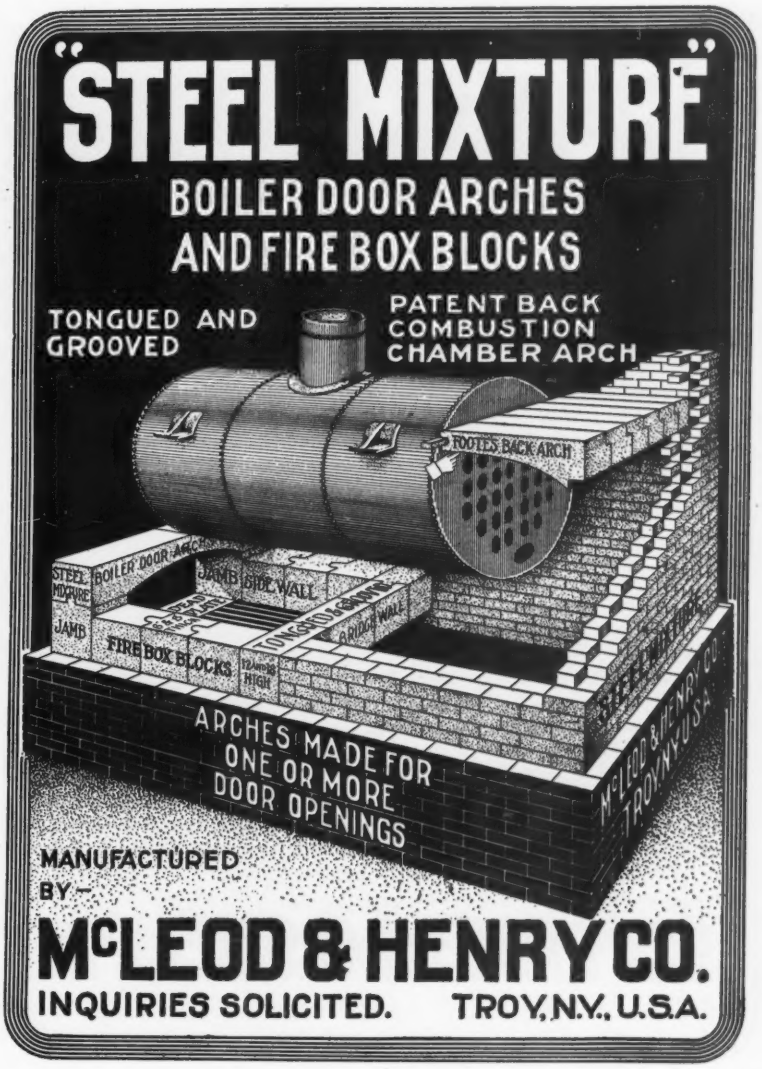

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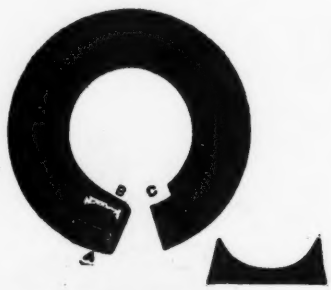

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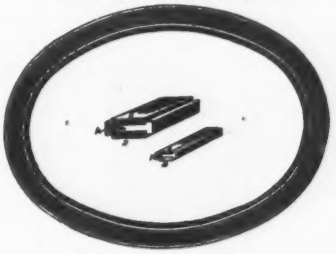

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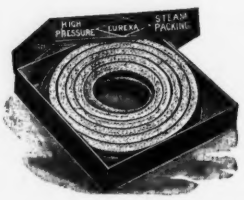

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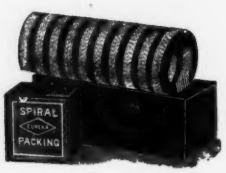

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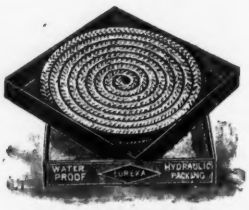

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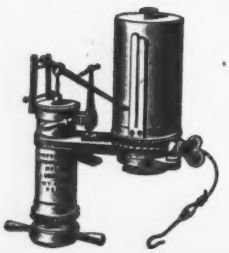

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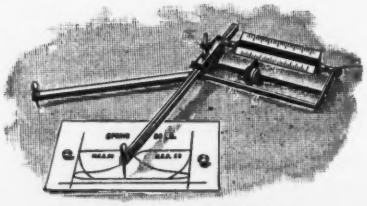

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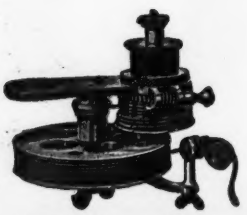

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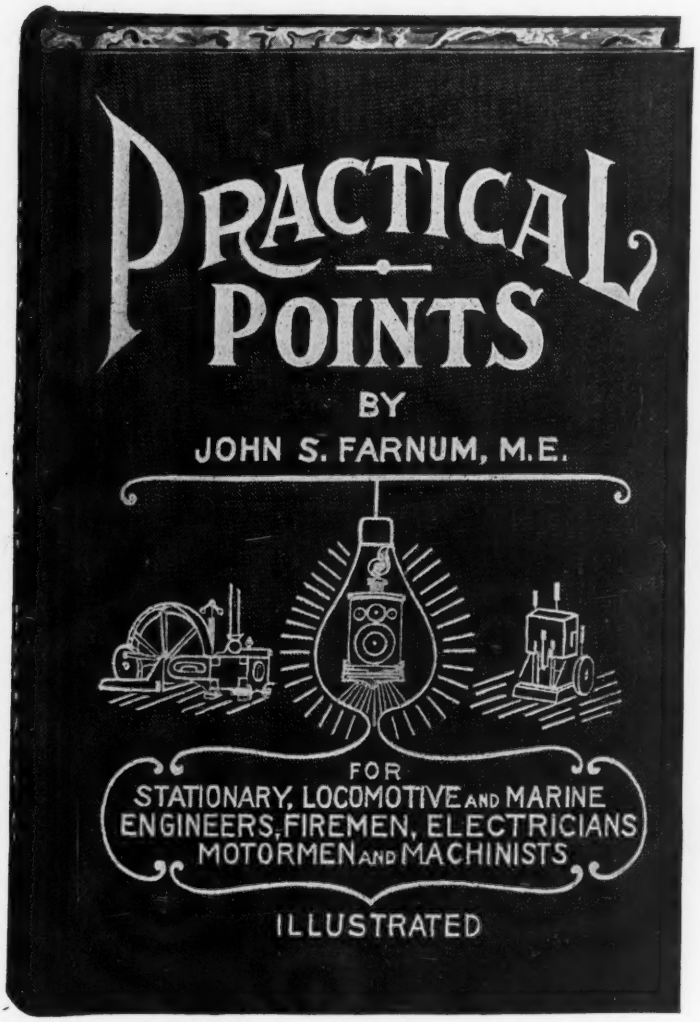

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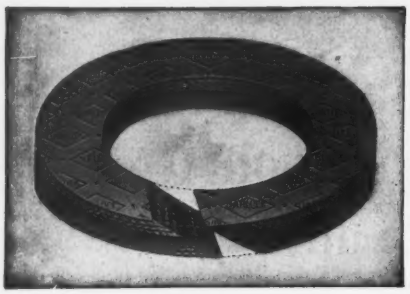

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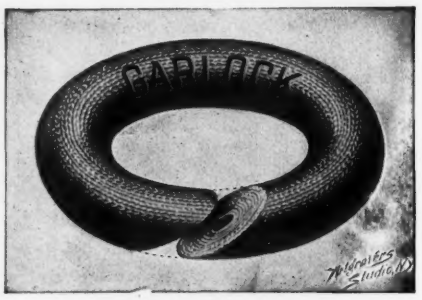

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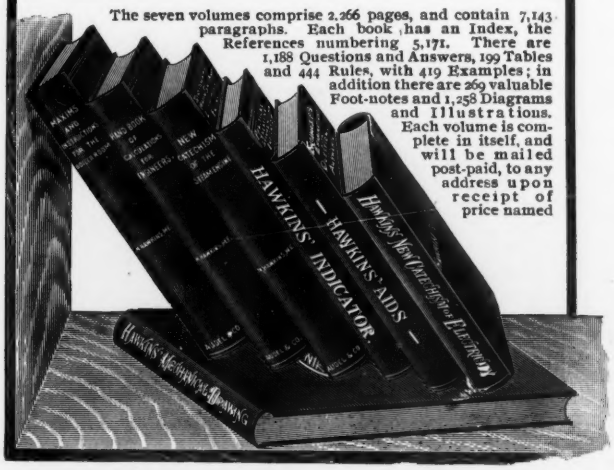

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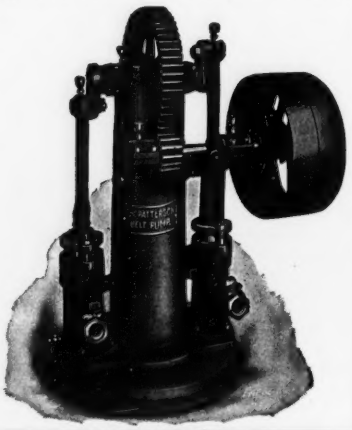

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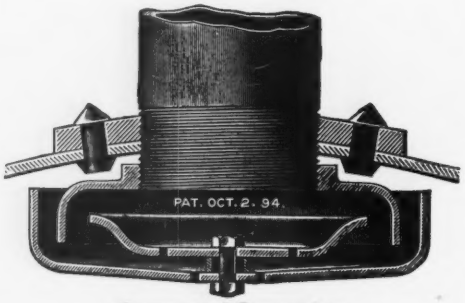

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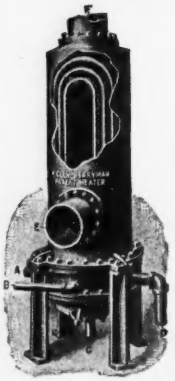

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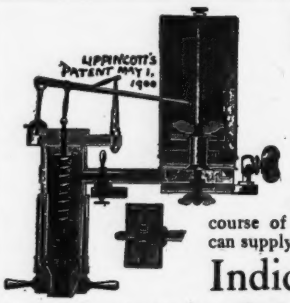

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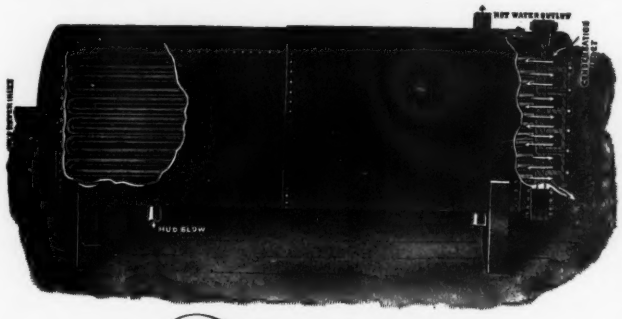

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THE

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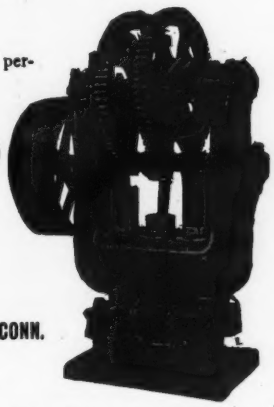

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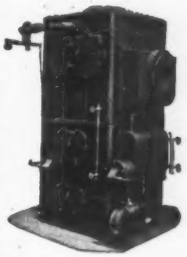

Then they save water—which costs money even to pump. The pure, hot condensation of the exhaust steam used in heating the water is made available for boiler feed water—taking the place of about one-seventh of the cold water that would otherwise be required.

Again, the purification of the water which these "Cochranes" accomplish prevents scale and saves money in two ways. By reducing the cost of cleanings and repairs and by increasing the heat-transmitting efficiency of the heating surfaces.

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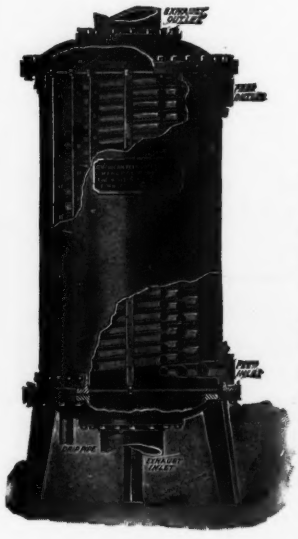

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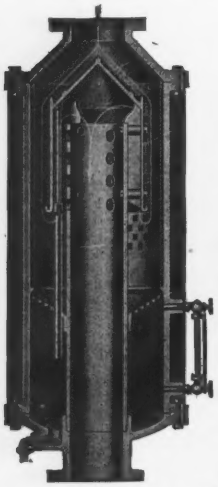

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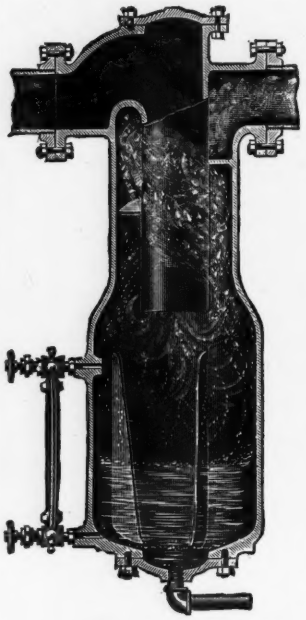

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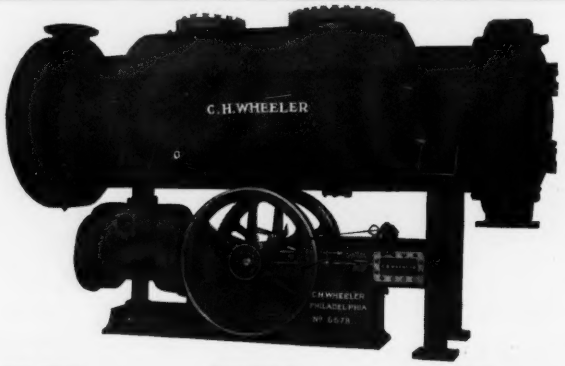

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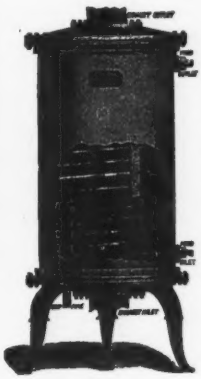

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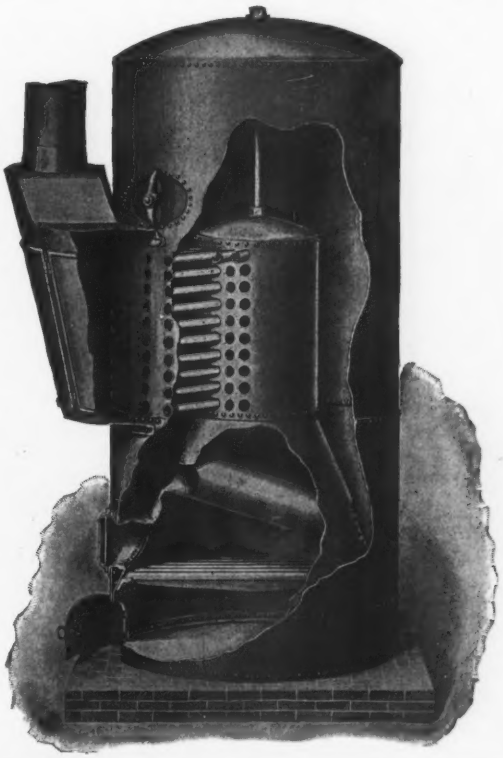

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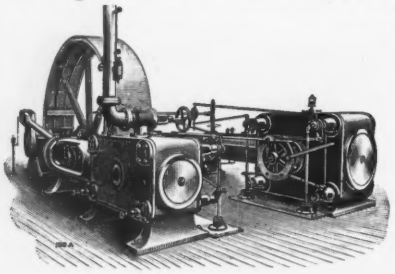

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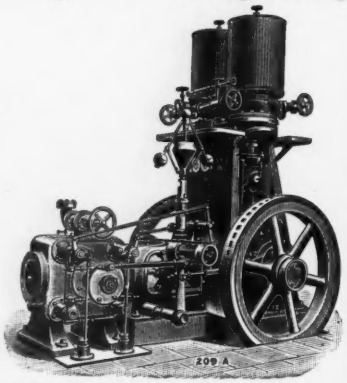

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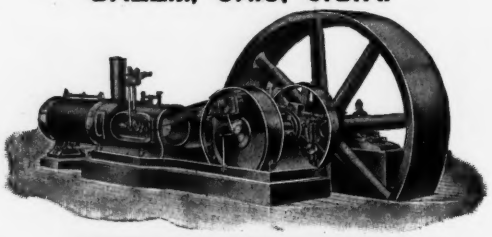

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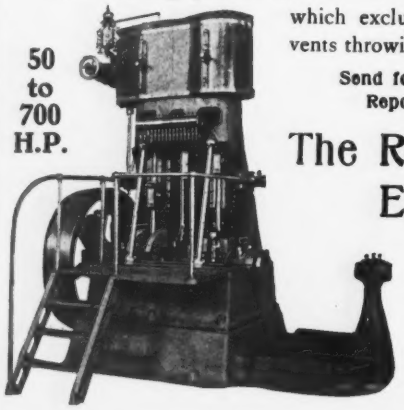

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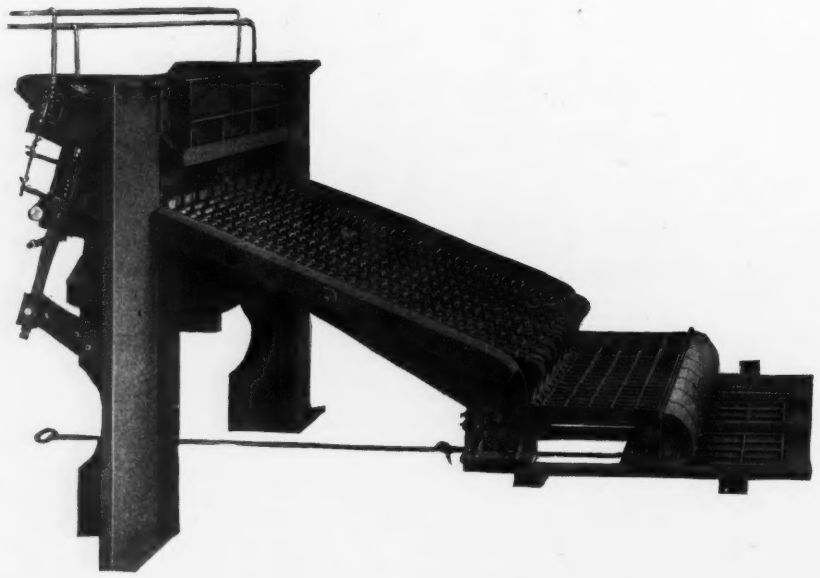

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will reduce the coal dealers bills, will abolish the smoke nuisance entirely and will save their cost times over. They feed the coal constantly, regularly and always in small quantities as required without opening the fire doors to admit injurious cold drafts on the boiler. They have a lot of other good features which we have not the space to tell you about here. If you are interested and wish to know more about them, write to us giving the number and size of boilers in your plant, and the kind of fuel you are using and we will give you some facts about the Wilkinson that will be worth a great deal to you.

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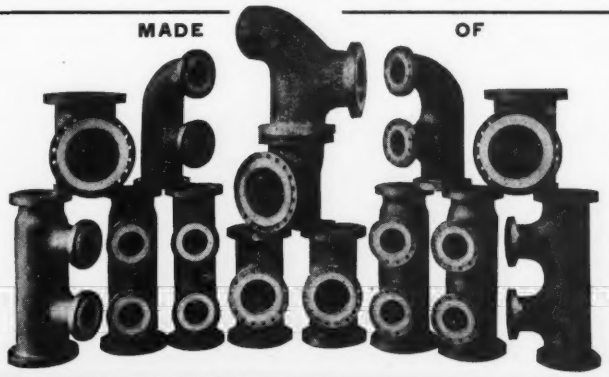

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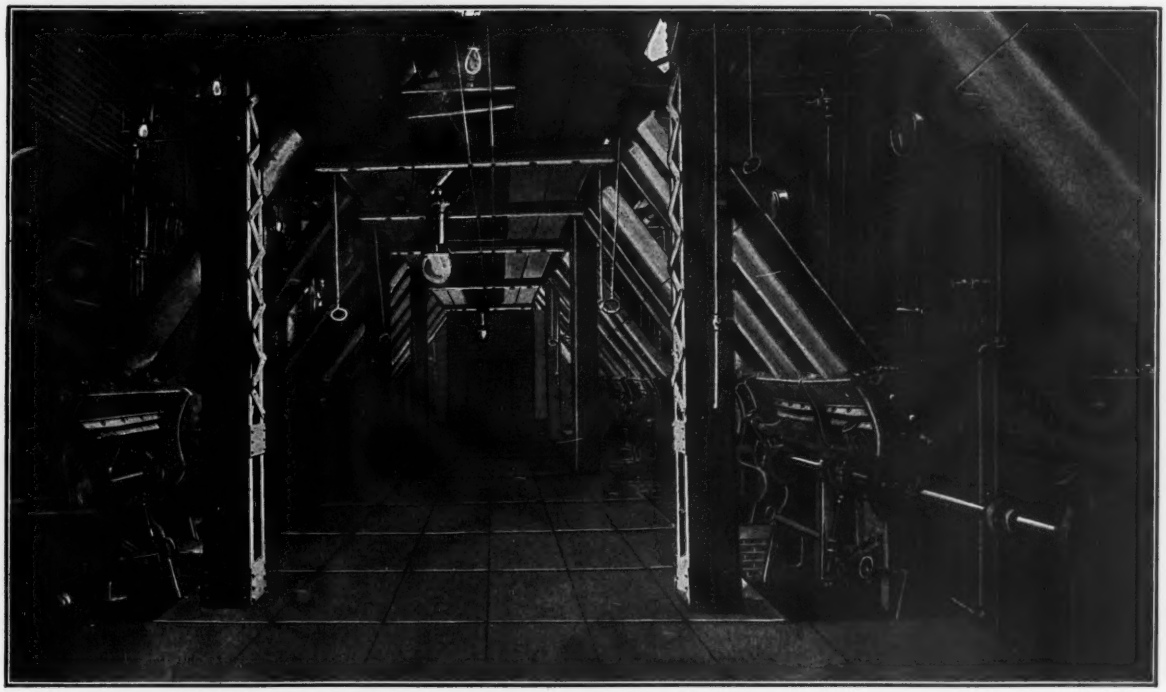

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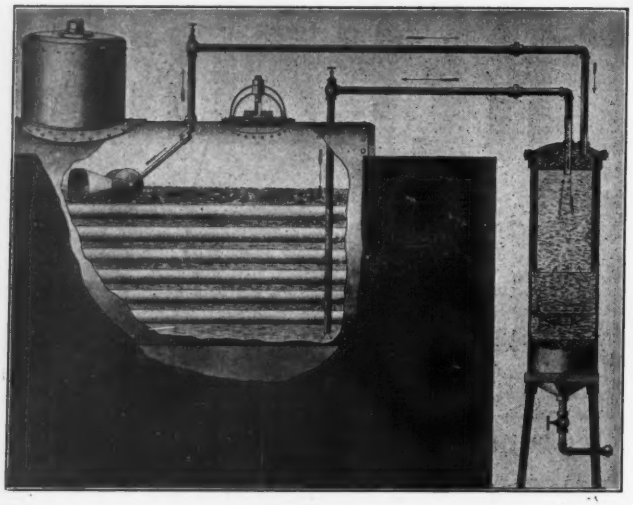

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will keep your boiler clean and free from scale or sediment without chemicals or other assistance. It is absolutely automatic, the skimmer is always floating exactly on the surface, whether the water is high or low, and is therefore always doing its full duty. It is the only floating skimmer on the market and the only known device that will keep steam boilers absolutely clean all the time without chemicals.

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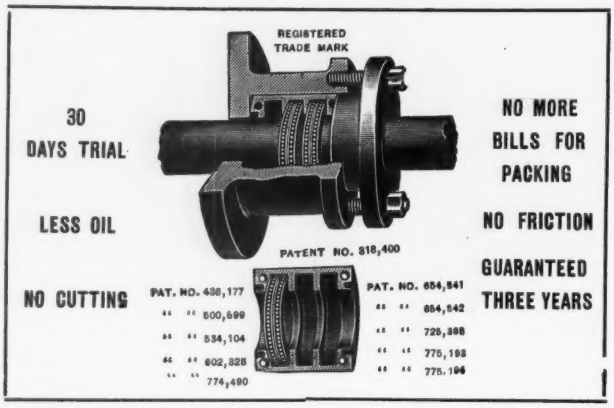

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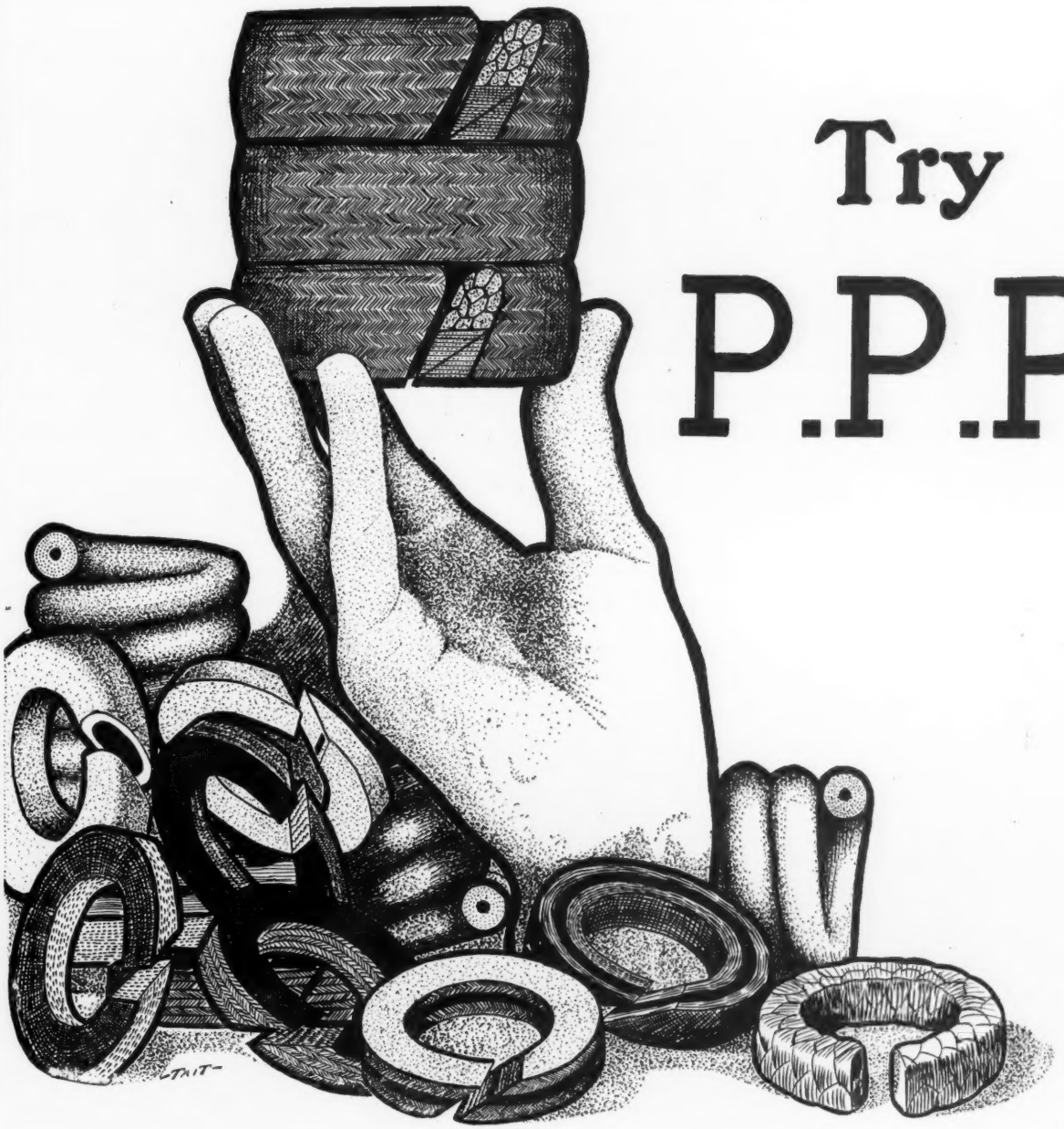

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Try 3 Rings

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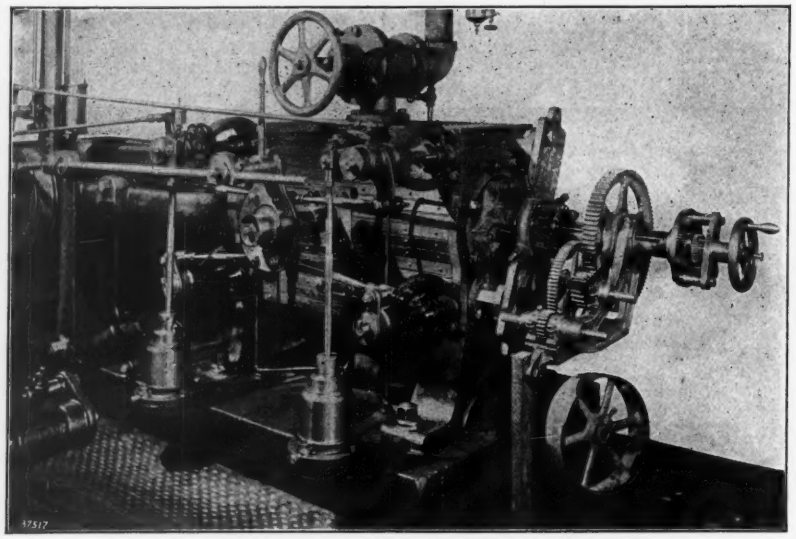

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One pound of KEYSTONE GREASE will last longer than 3 to 4 pounds of any other grease or 4 to 6 gallons of high grade oil.

We will send FREE (no charge now or afterward) to any engineer, A Large Size Sample Can of KEYSTONE GREASE, A Heavy Brass Grease Cup, and an Engineer's Cap. All we ask is the size of tap in which cup is to be used; H. P. of engine and R. P. M., of bearing, and the assurance that you will give KEYSTONE GREASE a thorough trial.

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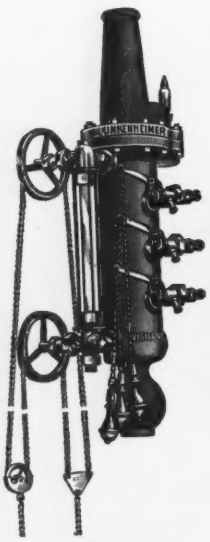

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The plug is automatically drawn tight to seat at each end of quarter turn allowing free movement of plug. Forget that an old style cock ever annoyed you and enjoy future peace with the Homestead.

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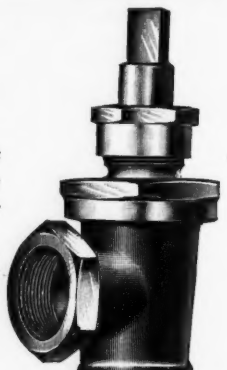

No other Angle Valve will stand the racket like this one, and none will give such thorough satisfaction. Made either screwed or flanged.

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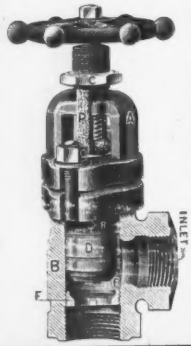
Powell Blow-Off Valve *The* "Cyclone"



Has outside screw and yoke top and the POWELL Packing gland. The wearing parts, both seat and disk are made reversible and renewable, that is, both have 2 faces, when one is worn, take it out, turn it upside down and bring the other in use. They can be reground any number of times. For your Boiler it cannot be equaled. Send for circular fully describing this valve. A trial is the most convincing way to demonstrate our claim of being the most acceptable of all Blow-off Valves. Manufactured by

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LIBERAL inducements in the shape of free samples, gifts of grease cups, etc., were employed to secure the introduction of the lubricant, but the results fully justified the wisdom of the methods adopted and the Company's confidence in the quality of the product.

Keystone Grease Grew On The Market

WITH its excellence once fully established and made evident to the practical engineer, the business of the Keystone Lubricating Co., expanded rapidly. Their extensive Manufacturing plant, of which we present some views, equipped with all the facilities required for the manufacture of Keystone Grease, was necessarily enlarged, from time to time, to keep pace with the increasing demand, and now includes everything required in the refining and compounding processes, to which, with the use of the best materials, carefully selected after analysis in a laboratory forming part of the establishment and scientifically treated, this superior lubricant owes its success. The emblematic Keystone of colossal

proportions, that adorn the entrance, is a conspicuous feature in a busy manufacturing town.

WITH the increase in demand came the necessity for improved business facilities, and here the Company's enterprise was again demonstrated. Their commodious offices, furnished with every modern business convenience, give employment to a large and compent staff, prompt attention to the multiplicity of affairs inseparable from so phenomenally rapid a growth, being one of the Keystones in the Company's record of success.

THE development of an important and flourishing industry is always a source of encouragement to the manufacturing community, especially where, as in the case of Keystone Grease, it is manifestly based on the merit of the product. Our readers, particularly the many who use this excellent lubricant, will doubtless find this brief account of its origin and progress of interest.

Keystone Grease will lubricate any and all kinds of machinery, and one pound will do more and last longer than three to four pounds of any other grease, or four to six gallons of high-grade oil.

We want to let you see for yourself that one pound of **Keystone Grease** will lubricate better and last longer than three to four pounds of any other grease, or four to six gallons of high-grade oil; and for this reason we will send **free** (no charge now or afterward) to any engineer who will send us his name and business address, a large sample

can of Keystone Grease, a Heavy Brass Cup and an Engineer's Cap, express paid; all we ask is for you to test **Keystone Grease** and to test it thoroughly. Also send us size of tap in which cup is to be used, H. P. of Engine, and R. P. M.

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